November 4, 1960

electronics

Simulated atomic explosion (below) occurs during war games between scale-model radio-controlled tanks. See p 55

Systems applications for solid-state masers. See p 58

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UNIVERSITY MICROFILMS INC
EDITORIAL DEPT
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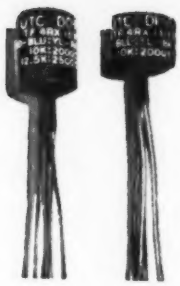
ANN ARBOR MICH

NEW* Revolutionary† DO-T and DI-T TRANSISTOR TRANSFORMERS

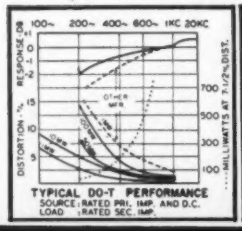
FROM STOCK—Hermetically Sealed to MIL-T-27A Specs.

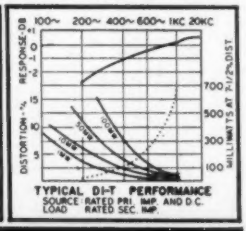


There is no transformer even twice the size of the DO-T and DI-T series which has as much as 1/10th the power handling ability . . . which can equal the efficiency . . . or equal the response range. And none to approach the reliability of the DO-T and DI-T units (proved to, but exceeding MIL-T-27A grade 4).

High Power Rating ..... up to 10 times greater.
Excellent Response ..... twice as good at low end.
Low Distortion ..... reduced 80%.
High Efficiency ..... up to 30% better . . . compare DCR.
Moisture Proof ..... hermetically sealed to MIL-T-27A.
Rugged ..... completely metal cased.
Anchored Leads ..... will withstand 10 pound pull test.
Printed Circuit Use ..... (solder melting) plastic insulated leads.
Suited to Clip Mounting ..... use Augat #6009-8A clip.

TRANSFORMERS PICTURED ACTUAL SIZE
DO-T: 5/8 Dia. x 1 1/32", 1/10 Oz.; DI-T: 5/16 Dia. x 1/4", 1/20 Oz.


100~ 200~ 400~ 600~ 1KC 20KC
RESPONSE DB
DISTORTION - %
MILLIWATTS AT 1% DIST.
TYPICAL DO-T PERFORMANCE
SOURCE: RATED PRI. IMP. AND D.C.
LOAD : RATED SEC. IMP.


100~ 200~ 400~ 600~ 1KC 20KC
RESPONSE DB
DISTORTION - %
MILLIWATTS AT 1% DIST.
TYPICAL DI-T PERFORMANCE
SOURCE: RATED PRI. IMP. AND D.C.
LOAD : RATED SEC. IMP.

DO-T No.	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Mw. Level	DI-T No.
DO-T1	20,000	.5	800	850	815	50	DI-T1
	30,000	.5	1200				
DO-T2	500	3	50	60	65	100	DI-T2
	600	3	60				
DO-T3	1000	3	50	115	110	100	DI-T3
	1200	3	60				
DO-T4	600	3	3.2	60		100	
DO-T5	1200	2	3.2	115	110	100	DI-T5
DO-T6	10,000	1	3.2	790		100	
DO-T7	200,000	0	1000	8500		25	
	500	0	100,000	—			
	Reactor 2.5 Hys./2 Ma., .9 Hy./4 Ma			630			DI-T8
DO-T8	" 3.5 Hys./2 Ma., 1 Hy./5 Ma.			630			
DO-T9	10,000	1	500 CT	800	870	100	DI-T9
	12,000	1	600 CT				
DO-T10	10,000	1	1200 CT	800	870	100	DI-T10
	12,500	1	1500 CT				
DO-T11	10,000	1	2000 CT	800	870	100	DI-T11
	12,500	1	2500 CT				
DO-T12	150 CT	10	12	11		500	
	200 CT	10	16				
DO-T13	300 CT	7	12	20		500	
	400 CT	7	16				
DO-T14	600 CT	5	12	43		500	
	800 CT	5	16				
DO-T15	800 CT	4	12	51		500	
	1070 CT	4	16				
DO-T16	1000 CT	3.5	12	71		500	
	1330 CT	3.5	16				
DO-T17	1500 CT	3	12	108		500	
	2000 CT	3	16				
DO-T18	7500 CT	1	12	505		500	
	10,000 CT	1	16				
DO-T19	300 CT	7	600	19	20	500	DI-T19
DO-T20	500 CT	5.5	600	31	32	500	DI-T20
DO-T21	900 CT	4	600	53	53	500	DI-T21
DO-T22	1500 CT	3	600	86	87	500	DI-T22
	600	5	1500 CT	—			
DO-T23	20,000 CT	.5	800 CT	850	815	100	DI-T23
	30,000 CT	.5	1200 CT				
DO-T24	200,000 CT	0	1000 CT	8500		25	
	500 CT	0	100,000 CT	—			
DO-T25	10,000 CT	1	1500 CT	800	870	100	DI-T25
	12,000 CT	1	1800 CT				

DO-T No.	Pri. Imp.	D.C. Ma.‡ in Pri.	Sec. Imp.	Pri. Res. DO-T	Pri. Res. DI-T	Mw. Level	DI-T No.
	Reactor 4.5 Hys./2 Ma., 1.2 Hys./4 Ma.				2300		DI-T26
DO-T26	" 6 Hys./2 Ma., 1.5 Hys./5 Ma.			2100			
	Reactor .9 Hy./2 Ma., .5 Hy./6 Ma.				105		DI-T27
DO-T27	" 1.25 Hys./2 Ma., .5 Hy./11 Ma.			100			
	Reactor .1 Hy./4 Ma., .08 Hy./10 Ma.				25		DI-T28
DO-T28	" .3 Hy./4 Ma., .15 Hys./20 Ma.			25			
DO-T29	120 CT	10	3.2	10		500	
	150 CT	10	4				
DO-T30	320 CT	7	3.2	20		500	
	400 CT	7	4				
DO-T31	640 CT	5	3.2	43		500	
	800 CT	5	4				
DO-T32	800 CT	4	3.2	51		500	
	1000 CT	4	4				
DO-T33	1060 CT	3.5	3.2	71		500	
	1330 CT	3.5	4				
DO-T34	1600 CT	3	3.2	109		500	
	2000 CT	3	4				
DO-T35	8000 CT	1	3.2	505		100	
	10,000 CT	1	4				
DO-T36	10,000 CT	1	10,000 CT	950	970	100	DI-T36
	12,000 CT	1	12,000 CT				
*DO-T37	2000 CT	3	8000 Split	195		100	
	2500 CT	3	10,000 Split				
*DO-T38	10,000 CT	1	2000 Split	560		100	
	12,000 CT	1	2400 Split				
*DO-T39	20,000 CT	.5	1000 Split	800		100	
	30,000 CT	.5	1500 Split				
*DO-T40	40,000 CT	.25	400 Split	1700		50	
	50,000 CT	.25	500 Split				
*DO-T41	400 CT	8	400 Split	46		500	
	500 CT	6	500 Split				
*DO-T42	400 CT	8	120 Split	46		500	
	500 CT	6	150 Split				
*DOT-43	400 CT	8	40 Split	46		500	
	500 CT	6	50 Split				
*DO-T44	80 CT	12	32 Split	9.8		500	
	100 CT	10	40 Split				
DO-TSH	Drawn Hipermalloy shield and cover 20/30 db						DI-TSH

‡ DCMA shown is for single ended useage (under 5% distortion—100MW—1KC) . . . for push pull, DCMA can be any balanced value taken by .5W transistors (under 5% distortion—500MW—1KC)

† DO-T & DI-T units designed for transistor application only. Pats. Pend.

* DO-T37 thru DO-T44 newly added to series.

And Special Units to Your Specifications

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November 4, 1960

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ENGINEERING

Radio-controlled model tanks come under simulated atomic fire during training maneuvers. See p 55 COVER

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Another NEW Jones & Lamson Optical Comparator
THE ECONOMY MODEL 14"-SCREEN PC-14A

This new 14"-screen universal measuring and comparison machine incorporates lateral, vertical and angle measuring facilities. It offers a combination of important features that set the standard for practicality, price, and performance:

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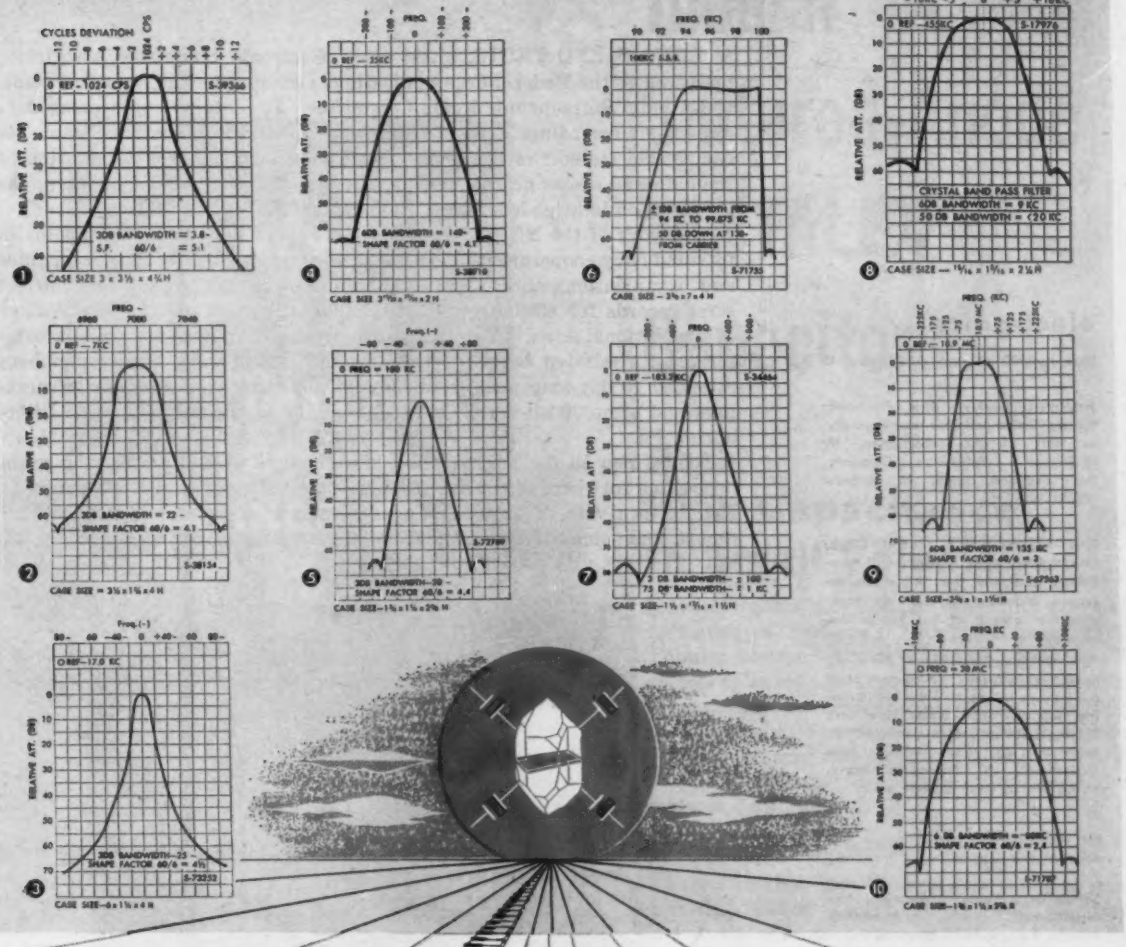
Jones & Lamson Machine Company, 539 Clinton Street, Springfield, Vt., U. S. A.

Typical response curves indicating the various shape factors available in standardized Burnell Crystal Filters



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1 kc to 30 mcs

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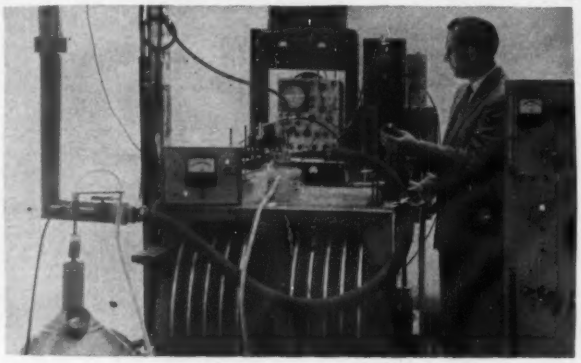
CROSSTALK

STEREO FIELD TESTS. Last week Electronic Industries Association delivered to the Federal Communications Commission the report of Panel 5, National Stereophonic Radio Committee. It contains engineering data and off-air recordings derived from field tests of six proposed systems for compatible stereo f-m broadcasting. The report makes no evaluation of the data and draws no conclusions favoring one system over another; the information is intended, rather, to help the FCC set standards.

The work of the NSRC field-test panel represents another highpoint in intraindustry cooperation. Some 36 engineers representing 23 companies and organizations and the FCC participated in the work. The job set some records for efficiency too. Under the direction of A. Prose Walker of the National Association of Broadcasters as chairman, the panel accomplished its mission between April 29 and October 17. Panel members attended 10 day-long panel sessions and joined in 12 subcommittee meetings and some 30 all-night field-test sessions at the test site near Pittsburgh, Pa.

To the men on the job and the companies and organizations who made it possible for them to be there, the electronics industry and the public at large owe a vote of thanks. For a summary of what is in the NSRC report, and some private speculation of what may come from it, see p 32.



SOLID-STATE MASER. Accompanying photograph appeared on p 66 of our April 25, 1958 issue. Showing an experimental setup in which a maser cavity is surrounded by high-voltage field coils, the photograph was part of an article on the solid-state maser amplifier by J. W. Meyer of MIT Lincoln Lab. Since that time, research has drastically reduced the size of the maser package. For a comparison, see Fig. 2A of Meyer's new article on masers which begins on p 58.

TUESDAY'S ELECTION will find millions of persons watching for an early balloting verdict—and that's where electronics comes in. The three major networks, American Broadcasting Company, National Broadcasting Company and Columbia Broadcasting Company, are using computer systems expected to give predictions earlier than in previous elections. One reason for this is the massive computer programming that has, in some cases, been going on for a year. The full story starts on p 30.

Coming In Our November 11 Issue

NEREM HIGHLIGHTS. When the Northeast Electronics Research and Engineering Meeting opens in Boston Nov. 15, a record-breaking attendance is expected at the 40 technical sessions and nearly 400 exhibits. Next week's conference roundup by New England Editor Maguire spotlights several significant papers to be presented in such areas as space and ocean electronics, information technology and microminiaturization.

electronics

Nov. 4, 1960 Volume 33 Number 45

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Designed to MIL-C-3965B

These Tantalex Capacitors are designed to meet vibration (2000 cycle), shock, and all other environment requirements of MIL-C-3965B. Outstanding mechanical features include a specially-treated cathode; a double-spun, missile-proven fluorocarbon elastomer high temperature seal; and a special porous sintered tantalum anode developed to give unusually high capacitance per unit volume.

No Shoulders; No Chassis Slots Required

The clean, shoulder-less shape of these capacitors was pioneered by Sprague to simplify printed wiring layout and assembly. It eliminates the need to punch mounting slots of the type required for older shouldered cup designs. Wiring boards can also be stacked more compactly.

For more information on Type 109D and 130D Tubular Sintered-Anode Tantalex Capacitors, write for Engineering Bulletin 3700D and Bulletin 3701 to Technical Literature Section, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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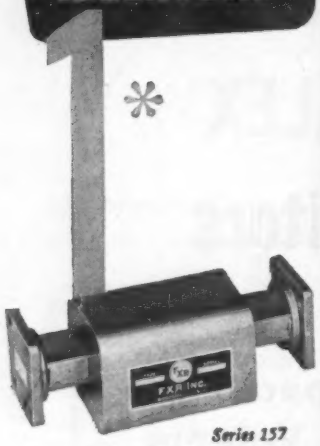

Series 157

- OPERATION: Full waveguide bandwidth
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- ISOLATION: 15 to 30 db depending upon range
- VSWR: Waveguide 1.15 max Coax 1.2 max
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W157A	7.05-10	24	*2KW	245.00
X157A	8.20-12.4	30	*2KW	220.00
Y157A	12.40-18	24	**1KW	245.00
K157A	18.00-26.50	24	**1KW	270.00
K157AF†				270.00
N157A	2.00- 4.00	15	**2KW	450.00

*Load VSWR 5 **Load VSWR 2
†K157AF has the same specifications as K157A, except for the flange.

Write for Catalog Sheet No. 157

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COMMENT

Space Systems

Your article entitled "Mercury Ground Network: Roadmap for Future Space Systems" (p 30, Oct. 7) presented the detailed system design in an excellent manner. It was noted that little mention was made of the acquisition aid to provide pointing data to all steerable FPS-16 antennas. This acquisition aid, produced by Cubic Corp., is called AGAVE, for automatic gimballed-antenna vectoring equipment. AGAVE is presently used in the Mercury program as well as all test sites on land, and also on ships where acquisition pointing data are required. We are proud of the AGAVE system because it provides a new tool for tracking heretofore unavailable.

I agree with your statements that there is an insatiable demand for more tracking capability, and that there is a growing emphasis on range and range-rate only tracking systems. Your attention is called to the Cubic-built Secor, a system which was sponsored by the Air Force and which is designed to provide range and range-rate. This equipment will be used by the Army in the next Transit flight to provide geodetic data for mapping the world.

This information is passed on to you because both AGAVE and Secor are systems that help supply the demand for "more tracking capability," and Secor has been designed specifically as a "range and range-rate system." It is interesting to note that the Secor overall cost—equipment and installation—is approximately a third that of the system in your article . . .

WALTER J. ZABLE
CUBIC CORP.
SAN DIEGO, CALIF.

Electromechanical Devices

Thank you for the . . . material covering "Electromechanical Devices and Systems for Electronics" (p 57, Sept. 30), including the cover with its fine picture of a ferreed. Incidentally, we would like everyone to use the term *ferreed* and have not, therefore, used a capital *F* in its spelling, as would be done for a trade name. This follows the practice of the term *transistor* and others.

Congratulations on a fine job. The field that you have covered is so large and so complex that you and your associates must have done overtime to do it so well.

A. C. KELLER
BELL TELEPHONE LABORATORIES
NEW YORK

. . . You have done an excellent piece of work in presenting the many different phases of the problems which concern electromechanical devices. I am sure that many more people are becoming aware of the fact that a relay as well as other switching devices require some understanding of the circuit conditions to obtain the proper device for a given application . . .

CHARLES F. CAMERON
OKLAHOMA STATE UNIVERSITY
STILLWATER, OKLA.

We felt that electromechanical systems were generally underplayed; but we didn't realize how badly until the response to the special report began to roll in.

We've found one mistake in the report that warrants correction. On p 59, the report says a meter relay can be actuated by changes in a signal as small as a fifth of an ampere; it should be a fifth of a microampere. We'd hate to let six missing zeros stand between meter relays and thousands of potential users.

Lost; Found

I have noted the letter "Help Wanted" published in Comment, p 6, Sept. 9, in which Mr. Gerald Shirley requests information on International Scientific Corp.

While you may already have received this same information, or perhaps more detailed information, I pass this along for what it is worth. The ISI magnetic clutch drive tape deck is now marketed by Mid-Continental Engineering, Minneapolis, Minn. I know this organization is currently in operation, as I ordered and received several parts for my ISI tape deck as recently as last month. . .

EUGENE A. WILLIE
U. S. ARMY SIGNAL RELAY CENTER
APO 58, NEW YORK

WHEN YOU NEED FAST SWITCHING specify new Hughes 2N1254-2N1259 P-N-P transistors

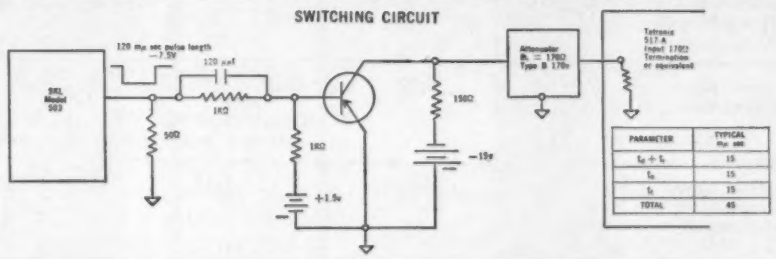
Here are the fastest switching p-n-p silicon mesa transistors ever developed. Look at these outstanding features: Typ. f_T of 75MC... thin base region...low stored base charge...low t_d t_r t_s t_f ... β of 1.5 min at 50MC... β of 1.75 typ. at 50MC...low collector capacitance. These transistors have good high-level gain characteristics, exceptional low-level gain characteristics, plus high breakdown voltage. They give excellent performance at low voltages, and they are *outstanding* for high-voltage switching.*

These new high-speed transistors are available in production quantities—right now!

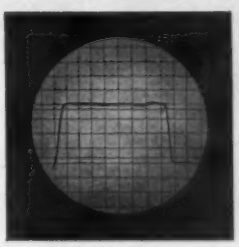
*The series is also available with the same electrical characteristics in a collector—grounded configuration with a free air power dissipation of 750 MW.

There is a Hughes sales office or authorized distributor in your area. Give them a call today. Or, if you prefer, write Hughes Semiconductor Division, Marketing Department, Newport Beach, California.

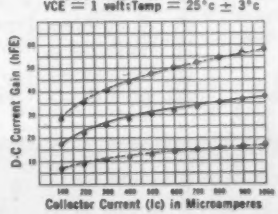
SWITCHING CIRCUIT



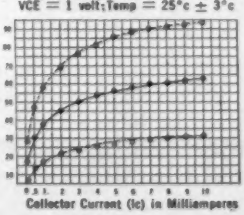
PARAMETER	TYPICAL mμ sec
$t_d + t_r$	15
t_s	15
t_f	15
TOTAL	45



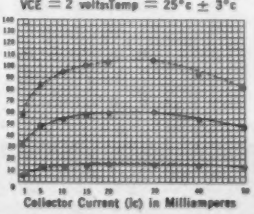
Types—2N1255, 2N1257, 2N1259
D.C. Current gain vs. Collector current
VCE = 1 volt:Temp = 25°c ± 3°c



Types—2N1255, 2N1257, 2N1259
D.C. Current gain vs. Collector current
VCE = 1 volt:Temp = 25°c ± 3°c



Types—2N1255, 2N 1257, 2N1259
D.C. Current gain vs. Collector current
VCE = 2 volts:Temp = 25°c ± 3°c



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MIL-W-76A

MIL-W-76A	DESCRIPTION (Single conductors)	VOLT RATING	CONDUCTOR SIZE	STOCK COLORS	ALPHA NUMBER
TYPE LW UNCOVERED PLASTIC	stranded tinned copper, light wall thermoplastic insulation. 80°C	300	20-30	*1-10 & *14-22	1685-1690
TYPE LW NYLON JACKET	stranded tinned copper, light wall thermoplastic insulation, clear nylon jacket overall.. 90°C	300	20-30	*1-10 & *14-22	1675-1680
TYPE MW UNCOVERED PLASTIC	stranded or solid tinned copper, thermoplastic insulation. 80°C	1000	12-24 (stranded) 16-22 (solid)	*1-30	1550-1567
TYPE MW SHIELDED	stranded tinned copper insulation, tinned copper shield overall. 80°C	1000	12-24	Conductors 16-24 Colors *1-10 Conductors 12-14 Colors *1-3	1350-1356
TYPE MW NYLON JACKET (SHIELDED)	stranded tinned copper, thermoplastic insulation tinned copper shield overall, jacket over shield. 90°C	1000	16-22	*1	1371-1374
TYPE MW NYLON JACKET	stranded tinned copper, medium wall thermoplastic insulation, clear nylon jacket overall. 90°C	1000	12-22	Conductors 16-22 Colors *1-10 & *14-22 Conductors 12-14 Colors *1-6	1504-1509
TYPE MW GLASS BRAID	stranded tinned copper, thermoplastic insulation, lacquered glass braid overall. 80°C	1000	12-22	Conductors 16-22 Colors *1-19 Conductors 12-14 Colors *1 & *14-22	1590-1595
TYPE MW GLASS BRAID SHIELDED	stranded tinned copper, white thermoplastic insulation, lacquered glass braid tinned copper shield overall. 80°C	1000	12-22	*1	1361-1366
TYPE HW UNCOVERED PLASTIC	stranded tinned copper, heavy wall thermoplastic insulation. 80°C	2500 (22-14) 600 (12-6)	6-22	Conductors 6-16 Colors *1-3 Conductors 18-22 Colors *1-10	1571-1579 & 1561-1567
TYPE HW GLASS BRAID	stranded tinned copper, heavy wall thermoplastic insulation, lacquered glass braid overall. 80°C	600	6-10	*1, 14, 15	1598-1599/6

1. White
2. Black
3. Red
4. Green
5. Yellow
6. Lt. Blue
7. Brown
8. Orange
9. Gray (slate)
10. Violet (purple)
11. Tan
12. Pink
13. Dark Blue
14. White/Black
15. White/Red
16. White/Green
17. White/Yellow
18. White/Blue
19. White/Brown
20. White/Orange
21. White/Gray
22. White/Violet
23. White/Black/Red
24. White/Black/Green
25. White/Black/Yellow
26. White/Black/Blue
27. White/Black/Brown
28. White/Black/Orange
29. White/Black/Violet
30. White/Black/Gray

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ELECTRONICS NEWSLETTER

New Rocket Programs For Moon, Planets

LUNAR AND PLANETARY PROGRAMS at Caltech's Jet Propulsion Laboratory will cost $50 million this fiscal year, 65-percent of this amount will be spent within industry. NASA lunar programs announced are Ranger, Surveyor and Prospector, with the latter two still in the study stage. Project Ranger will include five flights of a JPL-designed spacecraft launched by Atlas Agena B vehicles for 200 to 300-mph landings of 50-lb instrument packages on the moon. Surveyor will follow with a one-ton spaceship launched by Centaur rocket that will soft-land 100 lb of instruments. When Saturn vehicles become available, Prospector will provide roving experiments on the moon with possible return of lunar material samples to earth.

Planetary programs include orbiting of and landings on Mars and Venus by 1970. Possible objectives of other 1970 missions are fly-bys of Mercury and Jupiter. JPL spacecraft using Centaur will be called Mariner, and those using Saturn boosters, Voyager.

First Mariner mission will be a Venus fly-by in 1962. Second Mariner will be a deep space probe late in 1962. First Mariner Mars spacecraft will be launched in 1963. Developmental missions to Venus, using Voyager, will be conducted in 1965. Mercury and Jupiter flybys, using the Saturn C-2 vehicles, are scheduled for 1970.

Primary tracking station for Deep Space Instrumentation Facility is at Goldstone, Calif., with others at Woomera, Australia and Krugersdorp, South Africa. The Australian facility will be completed in November, the South African station in spring 1961.

MIT Laboratory Produces 150-Gc Varactor Diodes

OUTDIFFUSION TECHNIQUE has been used by MIT's Lincoln Laboratory to produce germanium varactor diodes with cutoff frequencies of 70 to 150 Gc at −1 v bias. Low-resistivity germanium doped with arsenic was outdiffused in a vacuum of 10^{-7} mm Hg at 850 C for 24 to 40 hours.

Outdiffusion produces a thin region of higher resistivity near the surface where an alloy junction can be formed, with the bulk of the material retaining its low resistivity. After outdiffusion, the germanium is lapped to 0.002-in. thickness and diced.

Ohmic contacts are formed through alloying the die to a gold-antimony plated Kovar stud. Dots are of lead-indium-gallium or indium-gallium, are alloyed onto the outdiffused region. Indium-coated nickel leads are soldered to the alloy dots and the junctions are etched. The packaged and sealed diode measures 0.27 in. long.

Plan Long-Term Geodetic Satellite

GEODETIC SATELLITE may be launched in near future for gathering of precise information about earth's gravity, size, shape and relationship between land masses. Some gravimetric information has come from satellites launched to date, but none has been specifically for geodetic measurements. Such a satellite is proposed by AF Cambridge Research Laboratories. It would use both optical and electronic equipment. Since repeated observations would be necessary for accurate data on the earth's size and shape, life expectancy of power sources for electronic equipment would have to be 9 months to a year.

Xerographic Process Reproduces Grey Scale

TABLE-MODEL electrostatic printer now being merchandised by American Photocopy Equipment Co. uses negative charge distribution on a paper coated with zinc-oxide resin to reproduce grey-scale tones. Charged sheet is exposed to a light image which reduces the charge in direct proportion to light intensity. Positively charged powder dusted on the surface makes the image visible; the powder is fused to the paper by heat.

Apeco calls the device Electro-Stat, envisions it as an office duplicator since its size is small (18 × 22 in.) and the cost of copies is 3.5 cents a sheet. The Electro-Stat uses an RCA-developed technique, will be produced under Apeco contract by Seeburg Corp.

Asks First Satellite For Telephone, Tv Tests

AMERICAN TELEPHONE & Telegraph last week picked up National Aeronautics & Space Administrator T. K. Glennan's cue (see ELECTRONICS Newsletter, p 11, Oct. 21) and asked authority to put up a satellite station within a year. Company wants the station for experimental transmission of telephone calls, television and other communications between the U. S., United Kingdom and continental Europe.

ATT asked Federal Communications Commission for the authority, said it was prepared to contract for the launching and to construct the ground transmission and receiving facilities. Spokesmen for the firm figure that communications satellites will cost about $1 million apiece when they are "in production."

Seek Transistors For 100-Mc Computer

TRANSISTORS for a future 100-Mc computer are goal of concentrated program at MIT Lincoln Laboratory. Sought is a uhf saturating, switching transistor capable of operating in 100-Mc computer circuits with rise-times in the order of one nanosec. Design is aimed at producing best uhf switching transistors of both madt and mesa types. It is hoped that high-speed amplifier transistors can be obtained by slight modification of the switching units. Under Lincoln contracts, Philco is working on madt approach and Texas Instruments on a new germanium mesa switch. Lincoln researchers are developing new techniques for measuring transistor parameters.

Study Detection Method For Near-Space A-Blasts

ATOMIC ENERGY COMMISSION announces development of an experi-

mental ground-based station for studying methods of detecting nuclear detonations in near space. Equipment was developed by Los Alamos Scientific Laboratory, has been operating atop the AEC's Los Alamos office since mid-September.

Station will investigate an atmospheric fluorescence phenomenon associated with high-level blasts, is part of project Vela, a cooperative detection project being carried on by AEC, Defense Department's Advanced Research Projects Agency, and government agencies.

Instruments and recorders were built by Edgerton, Germeshausen & Grier. Fluorescence detector uses a narrowband filter and an optical detector mounted behind a wide-angle lens. Technique has been proposed for inclusion in a worldwide network of ground detector stations now being discussed by a UN commission in Geneva.

New York City Testing Electronic Traffic Net

CENTRAL CONTROL STATION of New York City's Department of Traffic is now equipped with a high-speed, high-capacity punched-card programmer and accompanying gear to control a portion of the city's traffic electronically. Municipal officials studied traffic to derive forecasts of vehicular flow along a major artery in Queens County, programmed their control system according to these forecasts.

Control signals produced in the traffic center are sent by telephone circuit to a transmitter atop Queens General Hospital, broadcast by uhf radio to traffic-light control gear located at each intersection along Hillside Avenue.

The equipment was installed by Motorola, began operating last week, may be used more widely in the metropolis as initial testing proceeds. Several other large U. S. cities are now using equipment of the same type.

NASA Starts Studies Of Multi-Man Trips

NATIONAL AERONAUTICS & Space Administration has let three quarter-million-dollar study contracts on its Project Apollo, the three-man spacecraft system that may start flight tests in 1962. Convair, GE's missile and space vehicle department, and the Martin Company are making the studies, will turn the findings over to NASA in six months. Reports will include estimates of time, costs and facilities required for design, development, fabrication and flight test.

Manned orbital flights may be scheduled for 1966, with a trip to the moon before 1970. Total project will cost several hundred million dollars, NASA indicates.

Argonne Labs to Build High-Power Synchrotron

RAREST TYPES of antimatter will be available as tools for midwestern researchers within next two years, upon completion of Argonne National Laboratories' 12-billion-electron-volt zero-gradient synchrotron. Albert Crewe of University of Chicago's Enrico Fermi Institute for Nuclear Studies described the machine at an industrial conference in Chicago last week.

New machine will be able to accelerate 10^{13} protons per pulse, create even the most elusive particles now known. It will still have power to spare, Crewe says. The synchrotron will be bigger than the 10-Bev Soviet model.

One hundred twenty-four strategically focused quadrupole magnets will help 110-ft linear accelerator boost an 800-Kv ion source to 50-Mev level before injection into a sectional magnetic ring. Peak power in the ring is 117 megawatts. Changes in d-c will change the permeability of a ferrite tuning system which will alter the frequency of an r-f cavity, pushing the circling beam to top power.

The Question Now: When Stereo Standards?

ELECTRONIC INDUSTRIES ASSOCIATION has turned over the report of the National Stereophonic Radio Committee's Panel 5 to the Federal Communications Commission (see p 32-33, this issue). The question now is: When can the industry expect FCC to settle on stereo standards?

The field-test report of NSRC is not the last word. All proponents who had their systems tested still have the opportunity to file individual comments with FCC. Furthermore, manufacturers whose system were not tested (such as Philco, RCA, CBS) also can file. FCC men avoid suggesting that one system is superior to another, although they will point to desirable characteristics in nearly all the systems.

Barring a real dark horse in the stereo race, the best guess seems to be that stereo standards will be promulgated in the first half of 1961, and that the final system standard will be a hybrid of the systems already studied, plus best features of any later proposals.

Computers Beat Humans In Information Retrieval

COMPUTERS can double human effectiveness at indexing and retrieving information from libraries, Verner Clapp, president of Washington, D. C., council on library resources, told Computer Applications Symposium in Chicago last Wednesday. Needed however, are universally machinable languages.

In chemical association trial, machine retrieved 86 percent of source documents, compared to 38 percent by human team. Benefits could come from consolidating today's 3,000 indexing services into one searching tool.

Nanosecond Diodes In Production

GOLD-BONDED SILICON computer diode with recovery time of half a nanosecond was announced last week by Hughes Aircraft. The unit switches from 10 ma forward current to −6 v reverse voltage with less than 0.2 ns recovery time.

Hughes says rectification efficiency is 25 percent at 13.5 Gc. Typical capacitance is 0.7 pf. Applications proposed for the diode are in data-processing systems and high-frequency communications circuits.

Company spokesmen say that a technological breakthrough in the formation of the junction is responsible for the high speed of the unit. The diodes will cost $0.90 to $2.00 in lots greater than 100.

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50 db gain • 29 Mc bandwidth • Tunable 100 Mc**

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***Tubes in the range from 9.0 to 10.0 kMc tune 200 Mc.*

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ELECTRONICS ABROAD

British Using More Medical Tv Gear

MIDDLESEX—Conferees at recent meetings of the British Medical Association saw televised surgical operations and clinical procedures (see photo). The tv demonstrations were sponsored and produced by Smith, Kline and French Laboratories, Ltd. Projection receivers presented larger-than-life views of the operations on a 7 by 4 ft screen in color. Color tv cameras were made by E.M.I. Electronics Ltd.

French Conference Adopts Meter Standard

PARIS—The world got a new and more accurate international standard of length last month when the eleventh General Conference on Weights and Measures, meeting here, unanimously agreed to redefine the meter as 1,650,763.73 wavelengths of orange-red light emitted by the isotope krypton 86.

The new standard replaces a platinum-iridium bar kept in a vault outside of Paris since 1889. The isotope method, according to conference officials, makes it possible to check measurements to an accuracy of one-ten-millionth inch or better, compared to the limit of a millionth inch for the bar.

The conference also adopted an interim standard for time measurement of the second establishing the basic unit as the length of a second on January 1, 1900 at zero hours. Planned to replace the standard set at the turn of the century, it is a time unit based on the oscillation of a cesium atom. A time unit based on the earth's revolution, which varies, is no longer adequate for the space age, scientists at the conference agreed.

Canadian Group Scores Decision on Color Tv

TORONTO—The Canadian Board of Broadcast Governors' recent decision against early introduction of color television in Canada is disappointing to the nation's Electronics Industries Association, says general manager Fred Radcliffe.

He said that if Canadian industry had waited for public demand there would still be no good movies, hi-fi, stereo or oil burners in the country.

"Color television can only be exposed to the Canadian people by Canadian television stations being licensed to transmit it," he added. "Once Canadians have an opportunity to see for themselves how much better color tv is; once they have adequate programming and reasonable prices, then, in our opinion, they will demand it."

Japan Gets Train Reservation System

TOKYO—Electronic seat reservation system made for Japanese National Railways will soon be in service to handle reservations of all seats in the country's four crack express trains.

From a central magnetic memory drum storage unit, radio and wire connections will link stations and agents throughout the country. At each reservation location, cathode-ray tube displays will show the reservation situation for any coach in any of the four trains.

Atomic Reactor Planned for Finland

HELSINKI—Board of Governors of the Int'l Atomic Energy Agency has approved transfer of a U.S. research reactor and fuel to Finland. The transfer will be made through a three-way agreement between IAEA, Finland and the U.S. The reactor is a General Dynamics TRIGA Mark II, and will be set up at the Institute of Technology near Helsinki. This is the first transfer of special nuclear materials the international group has authorized. Expectations are that the fuel will be transferred free of charge in accordance with a proposal made by the U.S. last September to donate up to $50,000 worth of enriched uranium for Agency-sponsored research projects in 1960. Finland has agreed to accept inspections carried out under the International Agency's safeguards systems.

The TRIGA Mark II is a 100-Kw above-ground tank type.

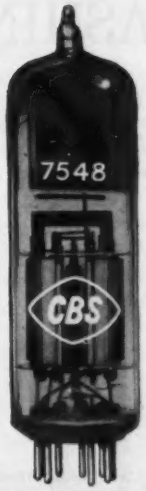
Czech Probe Unit Measures Magnetic Fields

PRAGUE—Disadvantages in measuring magnetic fields by the ballistic method or through rotating probes are reportedly overcome in a Czech instrument. The device is designed to speed up measurement of hysteresis loops of permanent nonmetallic magnets in a Neumann yoke.

The probe consists of a flat coil connected to a bent glass tube placed in a rubber socket. The bent end of the tube is connected to a piezo-electric crystal. An a-c current from a stable tone generator flows through the coil that is placed near the magnet to be measured. Frequency of the power current for the apparatus is chosen to correspond with the resonant frequency of the vibrating shystem. If the coil is in a d-c field, it vibrates when the power current flows, transferring the vibrations through the glass tube to the crystal. The a-c voltage on the crystal is directly proportional to the magnetic field strength.

Output voltage is displayed on a vtvm which is calibrated in oersteds.

Versatile Secondary-Emission Amplifier



NEW 7548 SOLVES CIRCUIT PROBLEMS NO OTHER TUBE CAN

PULSE GENERATOR/AMPLIFIER

- Less than 3 ns ultra-fast rise time
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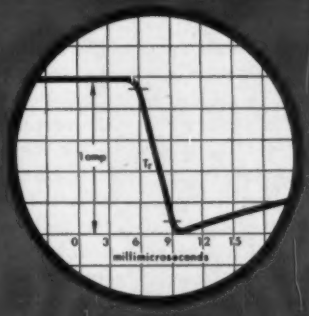
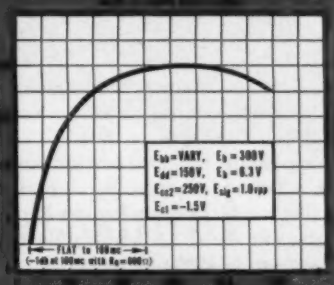
- 30 kc repetition rate at 100 ns pulse width



. . . AND WIDE-BAND CLASS A AMPLIFIER

- 350 gain-bandwidth product
- 26,000 μmhos transconductance at E_b = 300v and I_b = 18ma
- 3.4 μμf output capacitance



Enthusiastic response to the CBS 7548 established two major facts:

1. Keen interest in a practical, versatile secondary-emission tube.

2. Its limitless capabilities for simplifying and solving a wide range of circuit problems . . . from fast-rise-time pulse amplifiers and generators to wideband distributed amplifiers.

This new mass-produced version of the CBS 7548 easily outperforms conventional tubes and transistors, incorporates many new features and improvements based on customer requirements. Check the facts. Better still, order the CBS 7548 and Technical Bulletin E-393A. Put this problem solver to work in *your* problem circuits.

New mass-produced version offers many improvements

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- Exceptional stability under dynode overload
- Relaxed restrictions on dynode voltage
- Lowered threshold voltage requirements
- Output normalized, in or out of phase
- Relaxed regulation requirements for heater voltage
- Tested for shock and vibration
- Coil heater and high-conductivity gold-plated base pins
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- Standard 9-pin miniature base

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WASHINGTON OUTLOOK

THE DEFENSE DEPT. is taking a hard look at the controversial issue of acquiring proprietary technical data under defense contracts. The objective, as one official explains it, is to simplify and clarify the policy.

A wide-ranging survey is being made of major military installations and field agencies to determine their actual requirements for industrial proprietary data at the operating level.

The military services have long been caught up in the dispute between congressmen who plump for unrestricted dissemination of proprietary information to get broader competition on defense contracts, and industry, which seeks stronger protection for its proprietary secrets.

Up to now, the Pentagon has been reluctant to give in to congressional pressures. Its general view has been that a contractor's proprietary data should not automatically become government property.

THE AIR FORCE expects to issue a procurement instruction on value engineering within the next month. This will be the Air Force's first official attempt to cut production and development costs through such a formal program.

An Air Force official describes the forthcoming policy this way: "Where there is a reasonable assurance that there will be cost benefits, contractors will be directed to set up special engineering organizations devoting full time to get rid of design frills inadvertently cranked into systems and to assure that we get the best value for the least dollars."

In production contracts, incentive clauses will be included to allow the contractor to share the savings achieved through value engineering. The percentage allowed the contractor will be negotiated and will be based on the extent to which the contractor pays the cost to run the VE program. The Navy has allowed its contractors an average 50 percent of the savings achieved through value engineering.

As the Air Force policy now shapes up, engineering changes and cost savings resulting from VE efforts will be treated separately from cost reductions made under regular incentive provisions in fixed price contracts.

THE FEDERAL AVIATION AGENCY has spelled out a $163.2-million expansion program in air navigation and traffic control facilities this year—the largest expansion of its type to date.

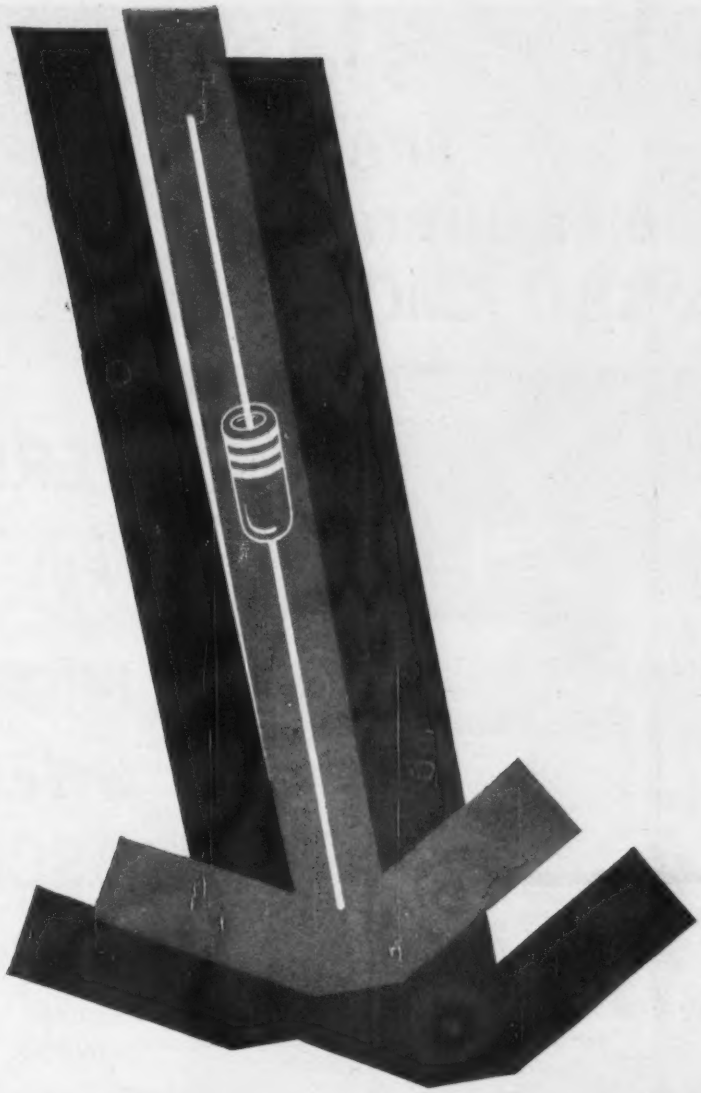
Thirteen long-range radars (costing about $2.4 million each) will be set up at ten air-route traffic-control centers; 41 radar bright displays ($405,000 apiece) will be installed at 22 centers; and 14 radar beacon systems will be put up at 13 long-range radar installations. Estimated cost of the last item is $293,000 each.

The expansion program also calls for establishment of 13 airport traffic control towers and 20 instrument landing systems; terminal very high frequency omnidirectional radio ranges at 17 airports; and new high-speed teletypewriter circuits at eight cities.

THE AEROSPACE INDUSTRIES ASSOCIATION has prepared a report outlining electronic requirements for aircraft, missiles, and space vehicles over the next decade.

The report forecasts a decline in the use of conventional electronic equipment and increased demand for microminiaturized parts and molecular electronics for use in equipment where weight and size are significant, requirements for precision tolerances are lessened, and heat-generating parts can operate at lower power levels.

It also predicts increasing demands for more precise positioning and tracking of airborne and surface vehicles by automatic controls and automated precision departure, terminal guidance, and landing or berthing of airborne and surface vehicles.



NEW CIRCUIT POSSIBILITIES

for low impedance, high current applications

SILICON SWITCHING DIODES

Combining high reverse voltage, high forward conductance, fast switching and high temperature operation, these diodes approach the ideal multi-purpose device sought by designers; they open new areas of opportunity for circuit design.

Type CSD-2542, for example, switches from 30 ma to −35v. in 0.5 microseconds in a modified IBM Y circuit and has a forward conductance of 100 ma minimum at 1 volt.

GENERAL PURPOSE TYPES

Optimum rectification efficiency rather than rate of switching has been built into these silicon diodes. They feature very high forward conductance and low reverse current. These diodes find their principal use in various instrumentation applications where the accuracy or reproducibility of performance of the circuit requires a diode of negligible reverse current. In this line of general purpose types Clevite has available, in addition to the JAN types listed below, commercial diodes of the 1N482 series.

MILITARY TYPES

JAN		SIGNAL CORPS	
1N457	MIL-E-1/1026	1N662	MIL-E-1/1139
1N458	MIL-E-1/1027	1N663	MIL-E-1/1140
1N459	MIL-E-1/1028	1N658	MIL-E-1/1160
		1N643	MIL-E-1/1171

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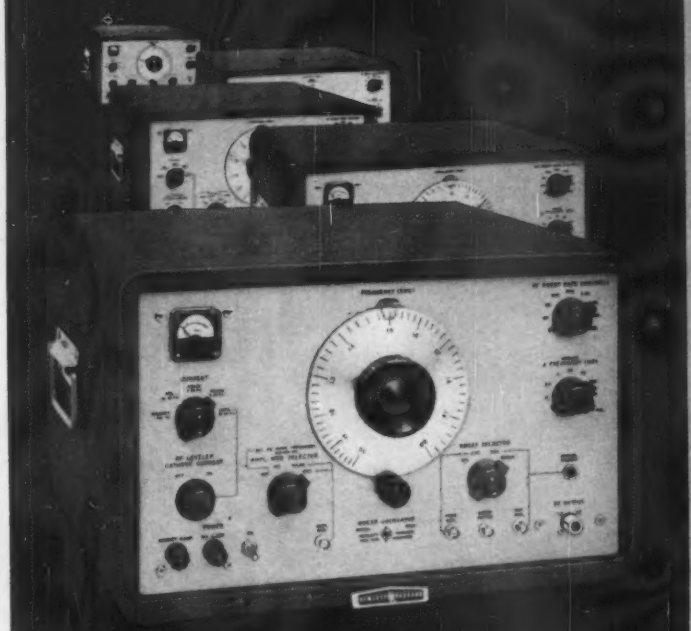

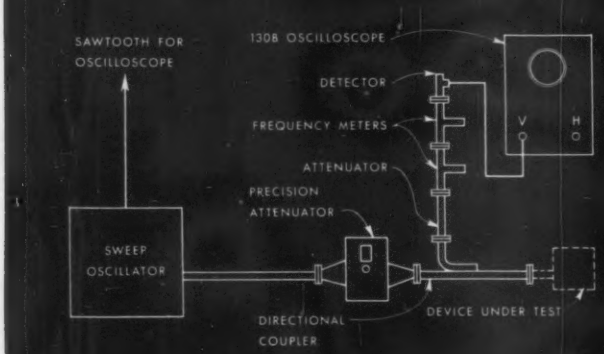

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Independently adjustable frequency, sweep range, sweep rate controls

Equipment arrangement for automatically displaying magnitude of reflection from device under test.

hp **Dependable, quality instruments**

Hewlett-Packard Electronic Sweep Oscillators are precision measuring tools deliberately designed to give you simpler, faster microwave measurements. Five models are provided, covering frequencies 1.0 to 18.0 KMC as follows: Model 682C, 1.0 to 2.0 KMC; Model 683C, 2.0 to 4.0 KMC; Model 684C, 4.0 to 8.1 KMC; Model 686A, 8.2 to 12.4 KMC, and Model 687A, 12.4 to 18.0 KMC.

These instruments make possible microwave investigations and evaluations with a convenience previously associated only with lower frequency measurements. Each oscillator provides a wide range of sweep speeds so that measurements of reflection, attenuation, gain etc., can be displayed on an oscilloscope or recorded in permanent form on X-Y or strip-chart recorders.

Electronic Sweeping

Specifically, the ϕ sweep oscillators provide either a CW or swept rf output throughout their individual bands. The instruments employ new backward wave oscillator tubes whose frequency is shifted by varying an applied potential. Thus, troublesome mechanical stops and tuning plungers are eliminated. Sweep range is continuously adjustable and independently variable; sweep rate is selected separately, and either can be changed without interrupting operation. The full band width can be covered in time segments ranging from 140 seconds (very slow for mechanical recorder operation) to 0.014 seconds (high speed for clear, non-flickering oscilloscope presentation).

Linear Frequency Change

The swept rf output from the ϕ sweep oscillator is linear with time, and a linear sawtooth voltage is provided concurrent with each rf sweep to supply a linear time base for an oscilloscope or recorder. In addition, for convenience in recording and other operations, rf sweeps can be triggered electrically externally and single sweeps can be triggered by a front panel push button. The rf output can also be internally AM'd from 400 to 1,200 cps and externally AM'd or FM'd over a wide range of frequencies.

Leveled Output

Models 682C, 683C, 684C provide leveled power output over their entire swept frequency ranges. An open-loop leveler is built into each instrument and provides leveled output without external equipment and at no extra cost. The leveler, which controls voltage on the grid of the backward wave oscillator tube, can be switched out of the circuit by means of a front panel control. Power variation over entire range: 682C, 683C $<\pm$ 1.5 db; 684C $<\pm$ 2 db; 686A (leveler not required) $\pm$ 1.5 db; 687A $\pm$ 4.5 db.

Rapid Visual Presentation

The variety of sweep rates and band widths available from the ϕ sweep oscillators insures convenience and accuracy for reflection and transmission coefficient measurements and many other production line and laboratory tests. For maximum speed, an oscilloscope such as ϕ 130B may be used as indicated in the diagram on opposite page. For maximum information and a permanent record, an X-Y or strip-chart recorder may be used.

Complete details of a rapid visual method using an oscilloscope or a maximum-data, permanent record method using a recorder may be obtained from your ϕ field engineer. Detailed discussions of these methods are also contained in the ϕ Journal, Vol. 8, No. 6, and Vol. 9, No. 1-2, available on request.

6741

TYPICAL SPECIFICATIONS

Below are specifications for 686A Sweep Oscillator, 8.2 to 12.4 KMC. Specifications for 682C, 683C, 684C, and 687A (P band) are similar except for frequency range and other minor variations.

Types of Outputs: Swept Frequency, CW, FM, AM.

Single Frequency Operation

Frequency: Continuously adjustable 8.2 to 12.4 KMC.

Power Output: At least 10 milliwatts into matched waveguide load. Continuously adjustable to zero.

Swept Frequency Operation

Sweep: Recurrent; externally triggered; also manually triggered single sweep. Rf sweep linear with time.

Power Output: At least 10 MW into matched waveguide load. Output variation less than 3 db over entire 8.2-12.4 KMC range.

Sweep Range: Adjustable in 7 steps 4.4 MC to 4.4 KMC.

Sweep Rate-of-Change: Decade steps from 32 MC/sec. to 320 KMC/sec.

Sweep Time: Determined by sweep range and rate; from 0.0139 to 139 seconds over full-band.

Sweep Output: Approx. + 25-volt-peak sawtooth provided at a front-panel connector concurrent with each rf sweep.

Modulation

Internal Amplitude: Square wave modulation continuously adjustable from 400 to 1200 cps; peak rf output power equals cw level $\pm$ 1 db.

External Amplitude: Direct coupled to 300 KC; 20 volt swing reduces rf output level from rated cw output to zero.

External Pulse: + 10 volts or more, 5 microsecond maximum duration.

External FM: Approx. 350 v peak to modulate full frequency range.

General

Input Connectors, Impedances: BNC; above 100,000 ohms.

Output Connector: Waveguide cover flange (686A, 687A); Type N, female (682C, 683C, 684C).

Sweep Width: Accuracy, $\pm$ 10% for full band sweep. + 25%-15% or $\pm$ 3 MC, whichever is greater, for other calibrated sweeps.

Linearity: Half-voltage point of sweep output occurs within 5% of mid-frequency.

Power Requirements: 115/230 volts $\pm$ 10%, 50/60 cps; approximately 540 watts.

Price: ϕ 682C (1.0 to 2.0 KMC)	$3,090.00
ϕ 683C (2.0 to 4.0 KMC)	3,000.00
ϕ 684C (4.0 to 8.1 KMC)	2,900.00
ϕ 686A (8.2 to 12.4 KMC)	2,900.00
ϕ 687A (12.4 to 18.0 KMC)	3,400.00

(Prices above are f.o.b. factory for cabinet models. Rack mount instruments $15.00 less.)

Data subject to change without notice.

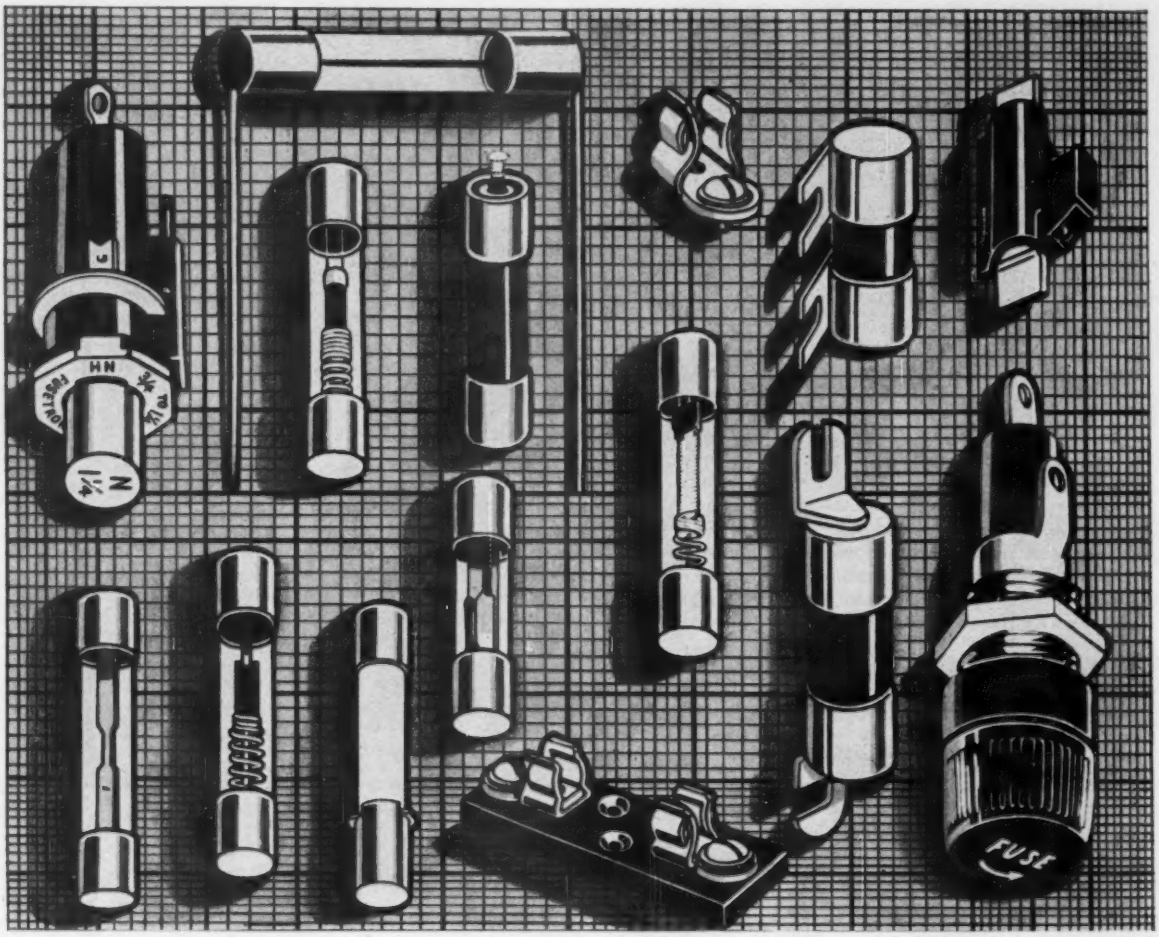
HEWLETT-PACKARD COMPANY

1056A Page Mill Road • Palo Alto, California, U.S.A.

Field Representatives in All Principal Areas

Cable "HEWPACK" DAvenport 6-7000

that speed and simplify your work



BUSS fuses can help protect

your product and it's reputation for quality

You get double protection when you specify BUSS fuses.

First, BUSS fuses are designed and manufactured to give maximum electrical protection.

But it doesn't stop there.

Every BUSS fuse is carefully tested in a sensitive electronic device that automatically rejects any fuse not correctly calibrated, properly constructed and right in all physical dimensions.

This is your assurance that BUSS fuses will operate as intended.

Second, BUSS fuses help protect your reputation as a quality manufacturer. A fuse that opens prematurely causes a needless shutdown. Likewise, one that doesn't function properly may cause other components to burn out or be damaged. In either case, it's an annoying headache for the customer who buys your equipment. More often than not, he will blame your product for his trouble.

With dependable BUSS fuses, you need have no worries that faulty fuses will give your product a bad name. That's why it makes good sense to specify BUSS fuses.

For more information on BUSS and FUSETRON small dimension fuses and fuseholders . . . Write for bulletin SFB.

BUSSMANN MFG. DIVISION
McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.

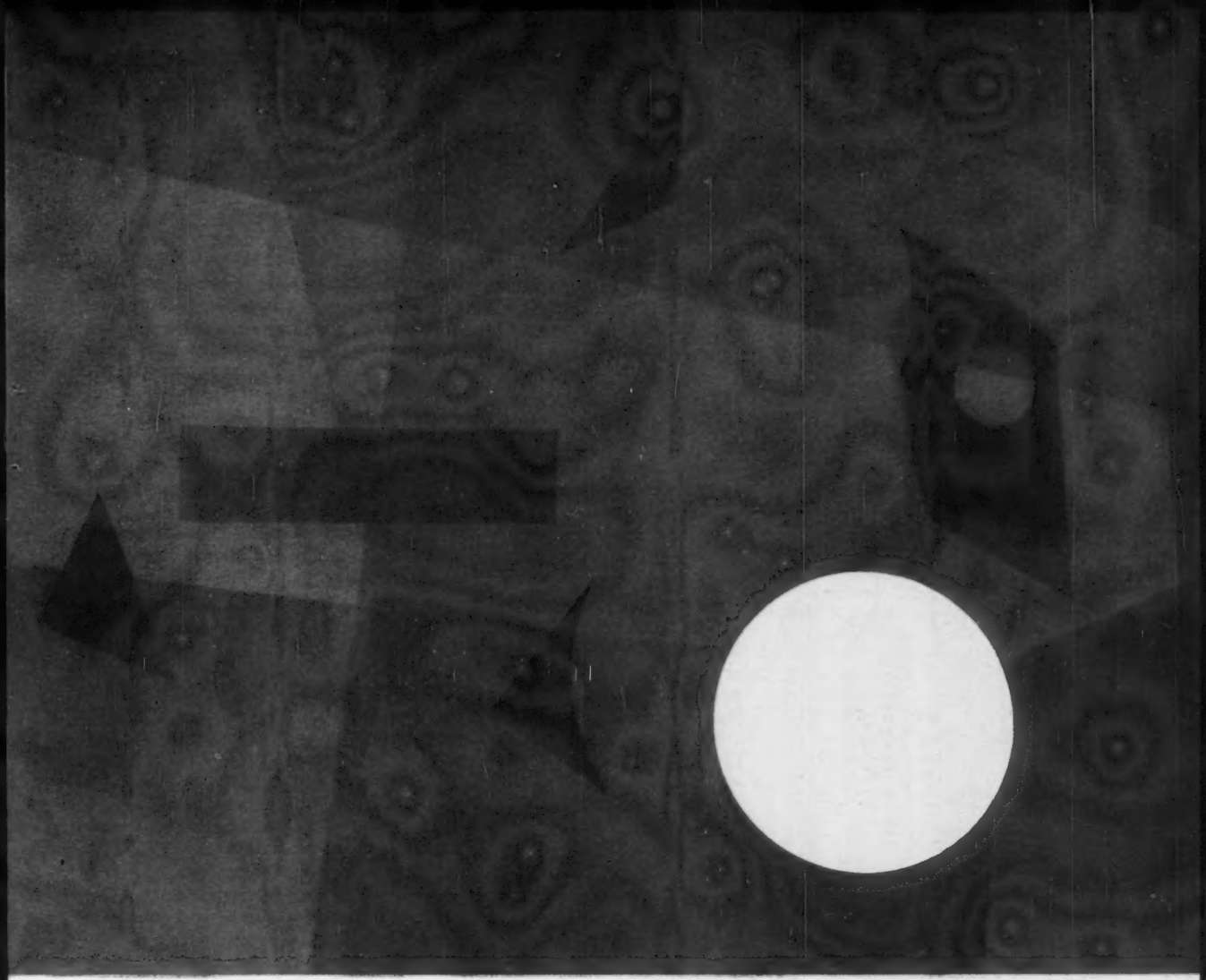
1060

BUSS FUSES ARE MADE TO PROTECT - NOT TO BLOW NEEDLESSLY

FUSETRON BUSS McGRAW EDISON

BUSS MAKES A COMPLETE LINE OF FUSES FOR HOME, FARM, COMMERCIAL, ELECTRONIC, ELECTRICAL, AUTOMOTIVE AND INDUSTRIAL USE.

CIRCLE 377 ON READER SERVICE CARD→



COMMUNICATION SYSTEMS . . . *the ultimate integration of the electronic arts*

Among the great names in the telecommunications and electronics industry, Kellogg today is one of the country's strongest sources of advanced communications equipments and systems. We have one major goal — to provide the finest communications that the electronic arts make possible . . . for industrial, commercial and military needs.

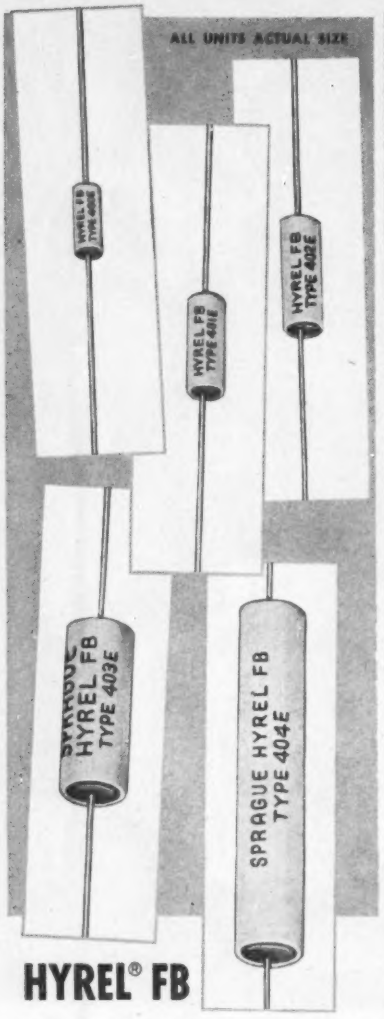
The Communication Systems Department of Kellogg, growing by leaps and bounds to keep pace with demands for wholly integrated communications means, provides large-scale communications systems from Alpha to Omega . . . from systems studies through engineering and production. Engineering is concerned with all phases of telephone, radio, data communications and automatic control circuit design. Principal areas of engineering organization include Project Engineering, Applications Engineering, Development and Systems Evaluation and Utilization and Reliability.

Typical of Kellogg's major systems engineering achievements is the provision of complete ground communications for the firing of Titan and Thor ballistic missiles and Discoverer and Samos space satellites at Vandenberg Air Force Base. Similarly, Kellogg has provided for the Atlas ICBM program nine separate systems for communication, control, maintenance and check-out, count-down, voice-recording and fire alarm — all functioning as an integrated system.

If you seek a dynamic organization in which to further your future, write Manager of Technical Staffing, Communication Systems Department, Dept. M-03(00).

ITT KELLOGG Communications Division, International Telephone and Telegraph Corporation

500 North Pulaski Road, Chicago, Illinois



HYREL® FB

DEPOSITED CARBON RESISTORS

UNMATCHED FOR PERFORMANCE

. . . hermetically sealed in ceramic jackets against moisture and vapor . . . safely protected against mechanical abuse. The Hyrel FB series is intended for applications in military, commercial and telephone equipment where long life under high humidity, small size, and stability of electrical characteristics are important.

WRITE FOR ENGINEERING BULLETIN 7010B

SPRAGUE ELECTRIC COMPANY

35 Marshall Street, North Adams, Mass.

Made to far exceed MIL-R-10509C Specifications

SPRAGUE®

THE MARK OF RELIABILITY

Form New SBA Investment Group

SMALL BUSINESS ADMINISTRATION announces licensing of another investment company specializing in electronics. The firm, **Electro-Science Investors Inc.**, Richardson, Texas, has initial capitalization of $7,280,000. SBA officials say this is the largest capitalization of any group it has licensed to date. The Texas company reportedly has also applied to **Securities and Exchange Commission** for authorization for a public offering of $8,250,000 in stocks. Board chairman of the new firm is J. J. Ling of **Ling Temco.** One vice president is R. E. Jacobson, an executive of **Thompson Ramo Wooldridge.** The secretary-treasurer is P. E. Broderick, an executive of **Dresser Industries.**

SBA also announced some new rulemakings. Prior to these changes, a company would be excluded from the small business category if its first public offering exceeded $300,000 or if its stock was traded over the counter or on one of the major exchanges. This rule no longer applies. Also changed is maximum net worth a company could have and be considered a small business. A ceiling of $2½ million has been established.

Radio Corporation of America announces that sales for the first nine months of 1960 topped the billion-dollar mark for the first time. Total sales for this period are up eight percent over the same period a year ago. The 1960 figure is $1,061,000,000. Net profits for the first three-quarters of this year amounted to $24,100,000 after federal income taxes, down 12 percent from net profits of $27,300,000 in the same period of 1959. Earnings this year were $1.46 a share on 14,882,000 shares.

Fairchild Camera and Instrument Corp., Syosset, N. Y., reports a net profit after taxes of $1.01 per share for the third quarter of 1960. Company profit for the first nine months of 1960 was $2,918,000, or $2.39 per share based on 1,219,206 shares outstanding. Total net profit for this year's third quarter, amounting to $1,236,000 after taxes, includes $268,000 of **Du-Mont** tax credit utilization, the minimum amount applicable to the period. In the third quarter of 1959 net profit was $580,000 or 48 cents a share, and the nine-month profit a year ago was $1,375,000 or $1.13 per share, based on the same number of shares. Net sales this year, for the first nine months, are up to $19,183,000, as compared with $11,645,000 for the same period of 1959.

Raytheon Company, Waltham, Mass., reports earnings from operations in the third quarter of 1960 were $1,952,000 after taxes. This is equal, after provision for preferred dividends, to 50 cents a share on 3,725,414 shares of common stock outstanding. In addition, the company reports a special gain of $5,040,000 (or $1.35 per share) received in connection with European production of the Hawk missile system. Profits during the period were $2,562,000, or 71 cents a share on 3,513,237 shares outstanding, after adjustment for shares issued for the merger this year with **Machlett Laboratories**, and the acquisition of **Sorensen and Co.** Sales in the third quarter this year of $125,266,000 topped those of $110,601,000 during the similar period a year ago. Sales for the first nine months of the year were $402,830,000, compared with $345,764,000 a year ago.

General Electronic Control, Inc., Minneapolis, has announced acquisition of **Standard Electrical Products Co.** of Dayton, O., and three Standard subsidiaries in Indiana, California and Puerto Rico. Net worth of the acquired firm is in excess of $1 million, and annual sales volume is more than $4 million. In the transaction,

GEC purchased 70 percent of Standard's 555,000 shares of privately held stock for an undisclosed amount of cash, 10-year notes and an exchange involving 35,000 of GEC common.

Westinghouse Electric reports nine-month net income after taxes increased eight percent this year to $60,680,000, or $1.71 a common share, over the corresponding period a year ago. Net income for the same period last year was $56,225,000, or $1.59 a common share. Net sales billed for the nine months of 1960 were $1,457,233,000, an increase of 3.5 percent over the $1,408,393,000 in the 1959 period. Provision for federal income taxes and foreign taxes in 1960 was $55,100,000, against $54,600,000 in the first nine months of 1959.

Daystrom, Inc., Murray Hill, N. J., for the six months ended Sept. 30, 1960, reports net income of $873,000 or 70 cents a share on 1,254,349 shares outstanding. For the corresponding six months of 1959, the net was $802,000, equal to 64 cents a share on the same number of shares. Sales for the first half of this year were $44,576,000, compared with $41,350,000 for the first half of 1959.

25 MOST ACTIVE STOCKS

WEEK ENDING OCTOBER 21, 1960

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Gen Tel & Elec	1,513	26⅞	25⅛	25⅛
RCA	761	54¼	48¾	48¾
Texas Inst	580	175	160	161
Gen Elec	518	75	73⅛	73½
Burroughs	378	31⅞	28⅜	29⅛
Litton Ind	346	79¾	73	73
Standard Kollsman	339	21¼	19½	19⅞
Philco Corp	305	20	18	18
Beckman Inst	298	86	81	81¼
Tel-Autograph	281	17¼	16	16⅛
Collins Radio	276	49⅞	45	45
Zenith	257	108⅜	100¾	100¾
Gen Dynamics	252	38⅞	36⅝	37⅛
Varian Assoc	245	46¼	40⅝	41¼
Gen Inst	222	35⅞	32¾	32⅞
Dyn Corp of Amer	206	8½	7¼	7⅜
Siegler	192	28⅝	25⅛	25¼
Cohu	187	8⅝	7	7¼
Amphenol-Borg	187	43	38¼	38¼
Int'l Resistance	168	30¾	26	26
Motorola	167	66¾	64⅛	65
Audio Devices	157	24¼	21¼	21¼
Electronic Assist	149	27⅝	22½	23
Amer Electronics	145	11⅞	10¼	10¼
Reeves Soncrft	119	7	6½	6½

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.

HELIPOT SINGLE-TURN POTENTIOMETERS...a line you can hang your toughest specs on! Don't worry, they can take it...environmentally, electrically, and mechanically! And you pay only for what you need, because Helipot offers 85°, 125°, and 150°C models! Standard linearity: ±0.5%, with ±0.10% available for most.
The Helipot line is simply stacked with stand-out single-turns, linear or non-linear, from ⅞" to 3" diameters. Numerous modifications are available for any of them—things like flatted or slotted shafts, rear shaft extension, shaft lock, anti-fungus treatment, color coding or center tap. And most models allow 8 cups to be ganged!
All these significant single-turns are precision built by Helipot...as are surprisingly large numbers of multi-turns, trimmers, A-C pots, dials, delay lines and in-line packages.
Want all the facts and figures? Just ask for our new catalog.
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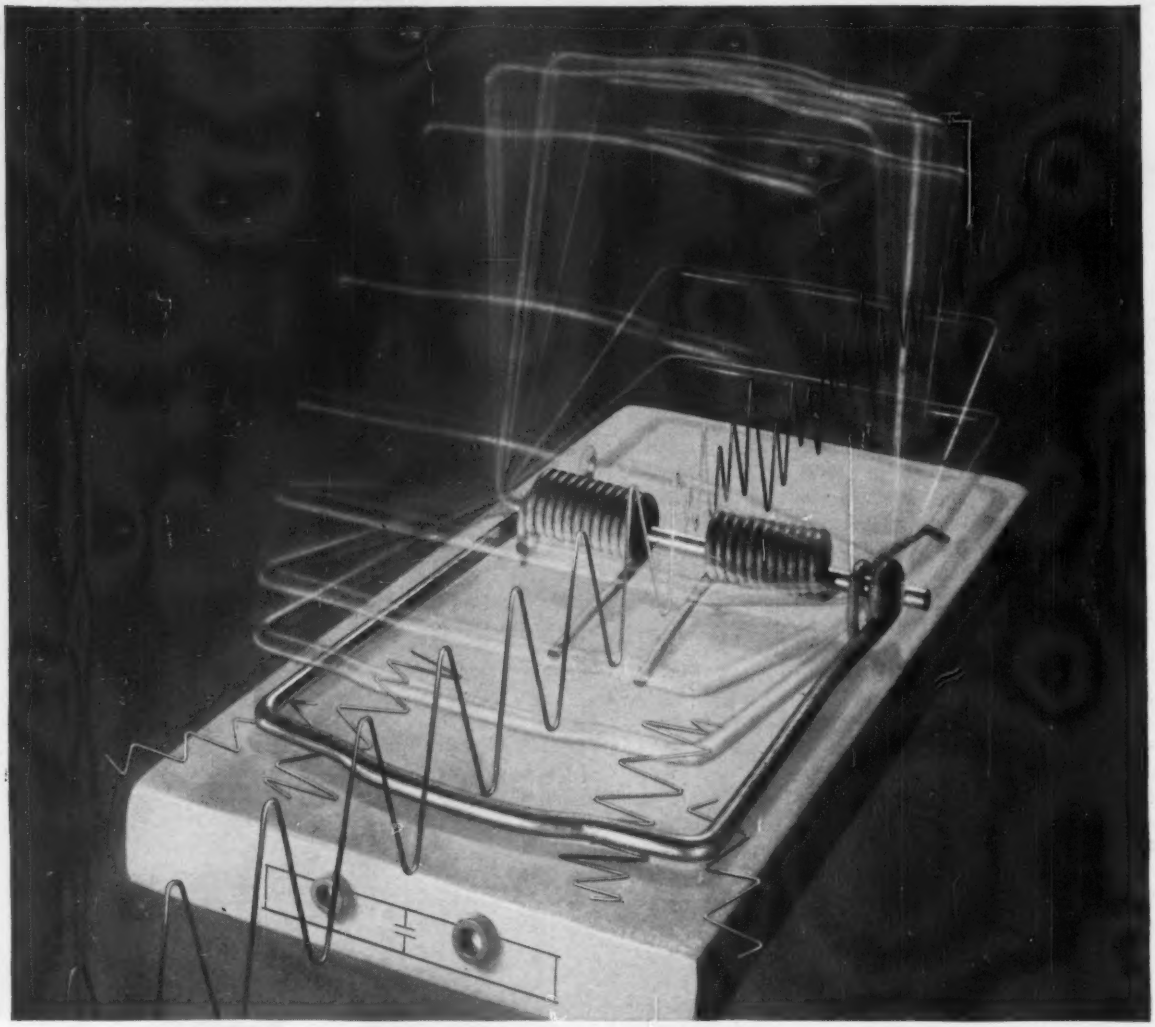
INSTRUMENTS IN YOUR FUTURE
25 YEARS
1935-1960



How to build a better (audio signal) trap!

Magnetics Inc. permalloy powder cores give filter designers new attenuation and stability standards—and miniaturization to boot!

The art of trapping unwanted frequencies has been advanced during the past year with a succession of improvements in molybdenum permalloy powder cores by Magnetics Inc. Most audio filter designers now work with smaller cores, more stable cores and cores whose attenuation characteristics are ultra-sharp. Do you?

Do you, for example, specify our 160-mu cores when space is a problem? With this higher inductance, you need at least 10 percent fewer turns for a given inductance than with the 125-mu core. What's more, you can use heavier wire, and thus cut down d-c resistance.

What about temperature stability? Our linear cores are used with polystyrene capacitors, cutting costs in half compared to temperature stabilized moly-permalloy cores with silvered mica capacitors. Yet frequency stability over a wide swing in ambient temperatures is increased!

And what do you specify when you must rigidly define channel cut-offs, with sharp, permanent attenuation at channel crossovers? Our moly-permalloy cores have virtually no resistive component, so there is almost no core loss. The resultant high Q means sharp attenuation of blocked frequencies in high and low band pass ranges.

Why not write for complete information? Like all of our components, molybdenum permalloy powder cores are *performance-guaranteed* to standards unsurpassed in the industry. *Magnetics Inc., Dept. E-82, Butler, Pa.*

MAGNETICS inc.®

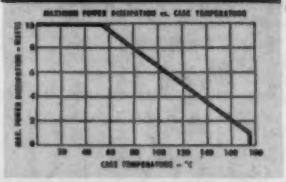
General Instrument Semiconductor

SHARPEST ZENERS AVAILABLE!

NOW... GI OFFERS YOU A COMPLETE LINE OF QUALITY ZENER DIODES

NEW 10-WATT ZENERS...

- *Extremely low Dynamic Impedance*
- *Superior Case Design*
- *Up to 175° C Operation*
- *Diffused Junction Type*
- *100% Scope Tested*



Outstanding Quality—New line of superior quality 10-watt zener diodes provides dependable uniformity of electrical characteristics... *completes* the family of General Instrument zeners. Unique case design, which employs thermal matching of silicon and package, enables units to withstand rapid temperature cycling and thermal shock. Low junction operating temperature means high reliability and long life. Conservatively rated diodes show extreme stability under life tests at maximum parameters.

New Diodes Available for Immediate Delivery in Types 1N1808; 1N2044 through 1N2049; and 1N1351 through 1N1362. Voltage ranges from 7.5 to 30 volts (higher upon request).

REPRESENTATIVE GROUP OF SUPERIOR ZENERS FOR YOUR MOST EXACTING CIRCUIT REQUIREMENTS... 10 WATTS TO ¼ WATT

(Standard types supplied ± 10% of stated value; ± 5% tolerances available except as indicated.)

New 10-Watt Zeners				3.5-Watt Stud Mount†				1-Watt Axial Lead†				¼-Watt Axial Lead			
Type	Zener Voltage (v)	Test Cur. @ 55° C (ma)	Max. Dyn. Imp. (ohms)	Type	Zener Voltage (v)	Test Cur. @ 25° C ma	Max. Dyn. Imp. (ohms)	Type	Zener Voltage (v)	Test Cur. @ 25° C ma	Max. Dyn. Imp. (ohms)	Type	Zener Voltage (v)	Test Cur. @ 25° C (ma)	Max. Dyn. Imp. (ohms)
1N1808	9.1	500	1	1N1588	3.6-4.3	150	2.6	1N1518	3.6-4.3	50	9	1N708	5.6	25	3.6
1N1351	10	500	2	1N1589	4.3-5.1	125	2.3	1N1519	4.3-5.1	40	8.5	1N714	10	12	8
1N1352	11	500	2	1N1590	5.1-6.2	110	1.4	1N1520	5.1-6.2	35	5.5	1N718	15	12	13
1N1353	12	500	2	1N1591	6.2-7.5	100	58	1N1521	6.2-7.5	30	1.6	1N721	20	4	20
1N1355	15	500	2	1N1592	7.5-9.1	80	.5	1N1522	7.5-9.1	25	1.1	1N723	24	4	28
1N1357	18	150	3	1N1593	9.1-11	70	.7	1N1523	9.1-11	20	1.5	1N731	51	4	115
1N1358	20	150	3	1N1594	11-13	50	1.4	1N1524	11-13	15	2.4	1N735*	75	2	240
1N1359	22	150	3	1N1595	13-16	40	3.4	1N1525	13-16	13	5.4	1N738*	100	1	400
1N1360	24	150	3	1N1596	16-20	35	6	1N1526	16-20	10	11	1N742*	150	1	860
1N1361	27	150	3	1N1597	20-24	30	9	1N1527	20-24	9	18	1N744*	180	1	1200
1N1362	30	150	4	1N1598	24-30	25	13	1N1528	24-30	7	28	1N745*	200	1	1400

*Supplied with ± 10% tolerance only. Intermediate values supplied with ± 5% tolerances on order.

CONTACT GENERAL INSTRUMENT for full technical information on the complete line of zener diodes, and for applications assistance on all your semiconductor needs.

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Flexibility
Reliability

PACKAGED LEAK TEST STATIONS

VEECO's MS-9 leak test consoles are packaged stations with guaranteed constant sensitivity. The helium mass spectrometer permits hermetically sealed units to be *certified* leak proof at a sensitivity of 10^{-10} std. cc/sec.

VEECO manufactures a complete line of high vacuum equipment... Components, Leak Detectors, Evaporators, Systems...accepted as the *quality* line for over a decade.

For MS-9 Brochure or Complete Catalog write Dept. 86V

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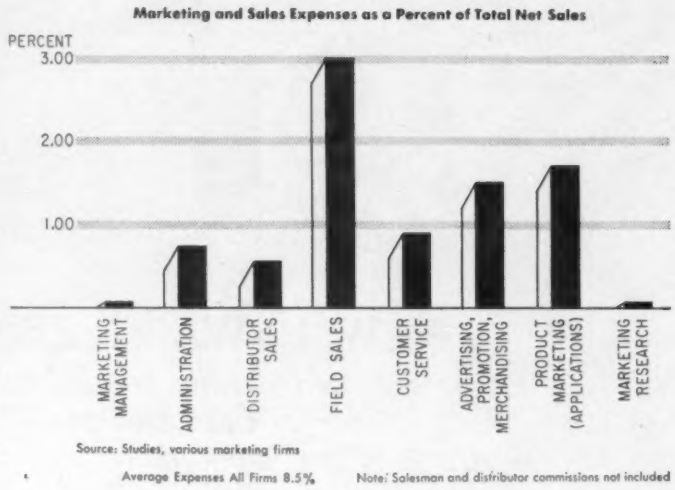
VACUUM-ELECTRONICS CORP.
Terminal Drive • Plainview, L. I. N. Y.
HIGH VACUUM & LEAK DETECTION EQUIPMENT

MARKETING

Sales Expenses Range From 5 to 11%



INVESTIGATIONS by semiconductor, capacitor, resistor and other manufacturers, show that sales expenses vary from 5 to 11 percent of total net sales, with the average running about 8.5 percent.

Single largest item of sales expense is field sales, 3.0 percent; followed by product marketing (product applications and modifications) 1.7 percent; advertising, promotion and merchandising 1.5 percent.

Illustration (above) lists other average expenses, including marketing management, market administration, distribution sales, (not including commissions), customer service, and marketing research. As illustration shows, marketing research is at the bottom of the list . . . with average expense of ½ of one percent . . . and investigators said many firms spent much less than this on marketing research.

Although these are average figures derived from actual expenses of many firms, users must realize that expenses of individual firms might vary tremendously from these averages. For instance, the marketing cost for introducing a new product could in the first year exceed total year's receipts.

Electronic Industries Association announces the appointment of George W. Westfall, formerly manager of sales and market research of Hotpoint division, General Electric Co., as marketing research director.

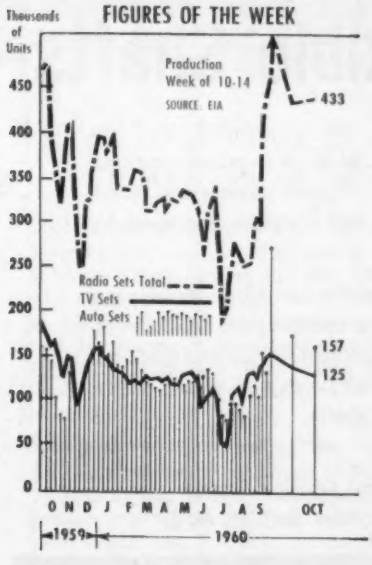
This new position was established by the EIA board of directors on recommendation of the association's Marketing Data Policy committee. Westfall's responsibilities will include the development or expansion of new marketing studies, especially in the industrial and military fields, as well as the direction of current programs. He also will be responsible for economic studies to assist

George W. Westfall

EIA in its industrial relations and import-export activities.

Richard E. Love has been appointed marketing manager of **The Budd Company's Instrument division.** In his newly-created position, Love will have responsibility for sales, marketing and promotion of the division's many product lines. **Jack B. Lehmann** has joined the marketing division of **Precision Circuits, Inc.,** designer and manufacturer of military and highgrade commercial printed wiring boards and assemblies. He will be responsible for directing the firm's sales engineering groups, in serving expanded markets in both industry and the military. . . . The appointment of **Jacob J. Repetto** as marketing manager is announced by **Clarostat Mfg. Co., Inc.,** Dover, N. H., manufacturer of resistance devices for the commercial and military markets. . . . **Richard C. Jones** has been named manager of microwave marketing for **Motorola.** In his new position, he serves as national manager of commercial microwave sales and supervises all marketing activities from headquarters in Chicago.

FIGURES OF THE WEEK



LATEST MONTHLY SALES TOTALS

(Source: EIA)
(Add 000)

	Aug. 1960	July 1960	Change From One Year Ago
Rec. Tubes, Value	$31,702	$28,810	+ 5.8%
Rec. Tubes, Units	38,540	34,883	+ 8.8%
Pic. Tubes, Value	$18,843	$13,898	+21.6%
Pic. Tubes, Units	928	682	+12.8%
Transistors, Value	$22,740	$18,084	+26.0%
Transistors, Units	9,733	7,071	+36.5%

BIRD

"Thruline" DIRECT READING Directional RF WATTMETER

MODEL 43

NOW! 2-30 mc
PLUG-IN ELEMENTS

An insertion type instrument used to measure forward or reflected power in coaxial transmission lines in the frequency range 2 to 1000 mc. Directional selectivity is accomplished by fingertip rotation of element to point arrow in direction of power to be measured. Calibration charts or full scale meter adjustments are not needed for this direct reading instrument.

The lightweight and portable Model 43 may be used on mobile or fixed equipment. It is recommended for accurate measurement of forward or reflected power... transmission line loss... insertion loss of components, such as filters, connectors, switches, relays, etc.... antenna matching work... continuous monitoring of transmitter output and... VSWR in complete systems in operation.

SPECIFICATIONS

Each model 43 Directional Wattmeter is made up of a line section, an indicating meter and plug-in measuring elements all contained in an aluminum case.

ELEMENTS: Available in the combinations of power and frequency ranges listed below:

FREQUENCY RANGE: 10 to 1000 Watts in six ranges. (2-30mc) (25-60mc) (50-125mc) (100-250mc) (200-500mc) (400-1000mc)

POWER RANGE: 10 to 1000 Watts in seven ranges: (10W) (25W) (50W) (100W) (250W) (500W) (1000W).

ACCURACY: ±5% of full scale

VSWR: Below 1.05 for complete unit and two connectors.

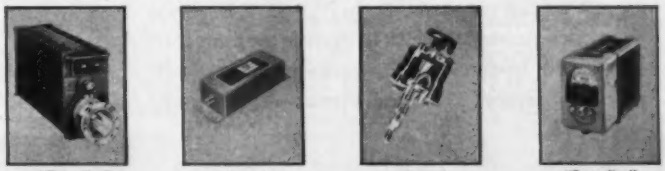
QUICK-CHANGE CONNECTORS: Two Type "N" FEMALE connectors which mate with (UG/21) Male "N" are supplied **UNLESS ORDER SPECIFIES OTHER CONNECTORS.** Other available quick-change connectors are Male or Female "BNC," "LC," "LT," "HN," "C," Male "N" and Female "UHF."

WEIGHT: 4 pounds

DIMENSIONS: 7" x 4" x 3"

BULLETIN #4360 Sent on Request.

OTHER BIRD PRODUCTS



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How to make a shrewd increase in recorder efficiency

With twice the performance, the Ampex FR-600 is still compatible with earlier equipment.

Doubles tape utilization and obviates standby equipment

Your FR-600 records 125 kc data at 30 ips instead of 60 — gives twice the recording time per reel. For example, you get 48 minutes recording time on 10½-inch reels, 96 minutes on 14-inch at 30 ips. Not only are tape expenditures cut in half, but standby recorders on long sessions may no longer be needed. And for a broader data spectrum in the future, your FR-600 can accommodate 250 kc at 60 ips or 500 kc at 120 ips.

Multiplies available recording time and eliminates error

Two-hour warmup and adjust sessions are reduced to ten minutes by the FR-600's transistorized circuitry. Final calibration is a one-time-per-use operation. Post-warmup stability — less than 1% drift per 24 hours — precludes time-wasting adjustments and minimizes creeping inaccuracies. Because your FR-600 is ready when needed, it works more hours per day, saving both your time and its own.

Updates performance of older equipment

The FR-600 plays back tapes from most existing data recorders. And because playback heads generally determine overall frequency response, use of an FR-600 for playback can permit earlier equipment (with simple adjustment) to record the same high information density as your FR-600.

The essential data

The Model: FR-600 Laboratory Recorder/Reproducer. *Number of tracks:* up to 14. *Reel sizes and tape widths:* 10½- or 14-inch NAB, with ½-inch or 1-inch tape, interchangeably. *Frequency response:* 300 to 250,000 cps ± 3 db at 60 ips with direct recordings; 0 to 20,000 cps ± 0.25 db at 60 ips in FM-carrier recording — proportionate response at other speeds. *Tape speeds:* 60, 30, 15, 7½ ips; 120, 3¾, 1⅞ ips optional. *Types of recording:* direct, PDM and FM-carrier, by plug-in modules. *Compatibility:* yes, with Ampex 300 and 800 series; FR-100 and FR-1100 series, and AR-200 and CP-100 series.

Write for full information

AMPEX DATA PRODUCTS COMPANY

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AMPEX

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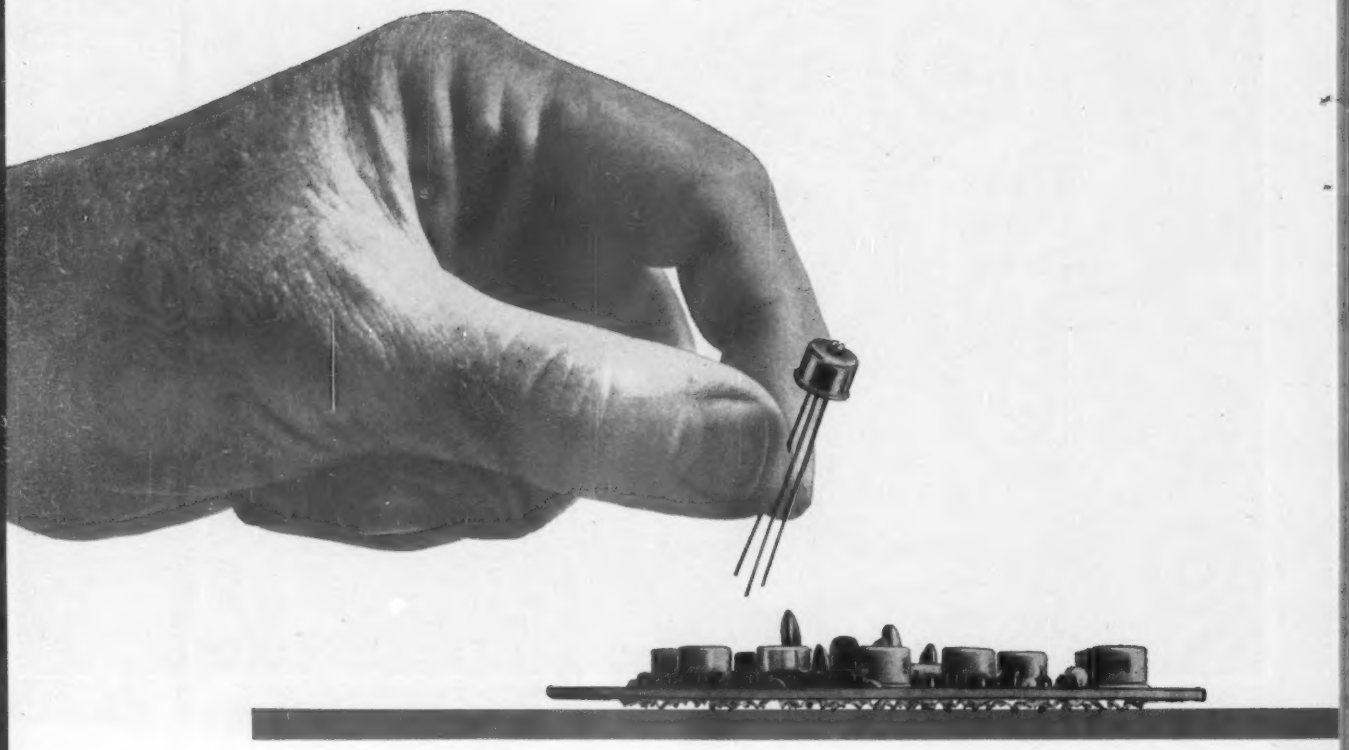
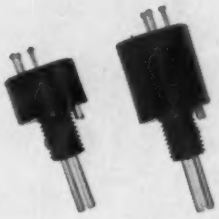


...it's the new Spectrol ultraminiature trimmer... the smallest trimming potentiometer on the market! Measuring 1/3" in diameter, weighing only 1 gram, and designed specifically for transistor circuits, the Spectrol Model 80 is a remarkable breakthrough in component technology.

Design engineers can now shrink printed circuit packages in all three dimensions. The single turn adjustment is from the top, rather than the side. It is ideal for printed circuit applications. Sealed construction allows complete package encapsulation.

THE MODEL 80 is approximately one-quarter the size of ordinary trimmers, yet it offers greater resolution and resettability because the resistance element is nearly twice as long. These trimmers meet all applicable military and commercial specifications including the most severe humidity cycling and immersion tests.

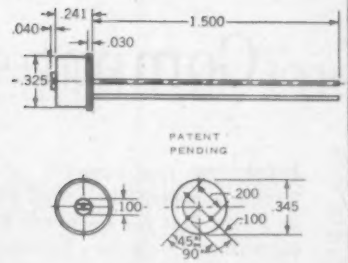
AND TWO NEW MINIATURE POTENTIOMETERS, TOO!



Sturdy construction provides reliable operation at a modest price. Only one-half inch in diameter, the new bantam weight Models 140 and 150 rotary potentiometers are well suited to trimming, control and servo applications where space and environmental conditions are critical. Standard linearity is ±1.0% with ±0.5% available on special order. Servo mount ball bearing type units have standard linearity of ±0.5%. Slotted shafts are standard on all models.

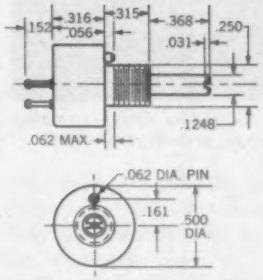
SPECIFICATIONS

MODEL 80



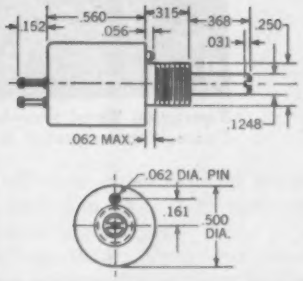
DIAMETER: 0.345"
STANDARD RESISTANCES (ohms): 50, 100, 200, 500, 1K, 2K, 5K, 10K
RESISTANCE TOLERANCE: ±5%
NO. TURNS: ONE
POWER RATING: 1 watt at 70°C
LINEARITY: ±1.0%
NOISE: 100ΩENR per NAS-710
SHOCK: 50 G
VIBRATION: 30 G to 2,000 CPS
HUMIDITY: MIL-E-5272C, Proced. I (10 days, cycling) and MIL-STD-202A, Method 104, Condition A (immersion in hot water)
SALT SPRAY: MIL-STD-202A, Method 101A, Condition A (96 hours)
LOAD LIFE: 1000 hours
WEIGHT: 1 Gram
PRICE (1-9 units): $6.00 each

MODEL 140



DIAMETER: 0.500"
STANDARD RESISTANCES (ohms): 50, 100, 200, 500, 1K, 2K, 5K, 10K
RESISTANCE TOLERANCE: ±5%
NO. TURNS: ONE
POWER RATING: 2 watts at 70°C
LINEARITY: ±1.0% standard, ±0.5% special (±0.5% standard on servo mount)
NOISE: 100ΩENR per NAS-710
SHOCK: 50 G
VIBRATION: 30 G to 2,000 CPS
HUMIDITY: MIL-E-5272C, Procad. I (10 days, cycling)
SALT SPRAY: MIL-STD-202A, Method 101A, Condition A (96 hours)
LOAD LIFE: 1000 hours
WEIGHT: 0.1 oz.
PRICE (1-9 units): $10.00 each

MODEL 150



DIAMETER: 0.500"
STANDARD RESISTANCES (ohms): 20K, 50K, 70K (50 ohms to 20K also available)
RESISTANCE TOLERANCE: ±5%
NO. TURNS: ONE
POWER RATING: 2 watts at 70°C
LINEARITY: ±1.0% standard, ±0.5% special (±0.5% standard on servo mount)
NOISE: 100ΩENR per NAS-710
SHOCK: 50 G
VIBRATION: 30 G to 2,000 CPS
HUMIDITY: MIL-E-5272C, Proced. I (10 days, cycling)
SALT SPRAY: MIL-STD-202A, Method 101A, Condition A (96 hours)
LOAD LIFE: 1000 hours
WEIGHT: 0.15 oz.
PRICE (1-9 units): $12.00 each

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Remington Rand president Dause L. Bibby (left) explains Univac's nerve center to Oliver Treyz, president of ABC

Programming techniques used election night may find application in marketing. Digital communications systems to be tested

Computers

PREDICTING the outcome of next week's presidential election will not be a new feat for electronic digital computers. Computers handled such chores when the art was still in its infancy. However, today's computers can do it quicker and their election-night work for the major networks effectively dramatizes their potential in marketing and other public-opinion analyses.

Compiling statistical data for the election-night computer work has taken about a year. Feeding in early returns next Tuesday will be a large-scale effort.

Pollstering for ABC will be a Remington Rand Univac I, which predicted Eisenhower's 1952 victory two hours after the first polls closed. RCA's 501 electronic data processing system will be put to work by NBC. CBS will use a 7090 computer in IBM New York data center.

Univac I can execute about 2,000 instructions a second, uses a mercury memory to store 12,000 digits or alphabetical characters in 1,000 locations and upon instruction brings them out in 40 microseconds, adds or subtracts at 1,905 digits a second, performs 465 multiplications and 257 divisions a second, makes, comparisons at 2,740 a second. Although adequate for elec-

NBC newsman Richard Harkness discusses data processing with operator of RCA 501 computer, part of company's Wall St. service center

CBS commentators Walter Cronkite (left) and Howard K. Smith (right) confer with engineer on election night operation of IBM 7090 computer, which is solid-state successor to the 709 and is used in missile design

Ready for Tuesday's Election

tion predicting, this performance does not compare with that of later Univac data processing systems which have replaced much of the 80 miles of wiring and all of the 5,000 vacuum tubes with solid-state components. Univac III, the latest Univac system, executes 110,000 instructions a second, transfers 133,300 alphanumeric characters from tape to a magnetic core memory and brings them out in 4.5 microseconds, adds or subtracts at 111,111 a second, performs 13,072 multiplications and divisions a second, makes 5,555 comparisons a second.

Since last spring, Univac I has been primed with $500,000 worth of election data programming. Early predictions based on first returns will be announced over ABC-TV election night news programs. Later, the election coverage will switch from the tv studio to the Univac Service Center in New York City.

The solid-state IBM 7090 has computing speed six times faster than that of its vacuum-tube predecessor, the IBM 709. This general purpose data processing system is intended for design of missiles, jet engines, nuclear rockets and supersonic aircraft.

It can simultaneously read and write at the rate of 3,000,000 bits of information a second, locates and makes ready for use 32,768 data or instruction numbers (each of 10 digits) in its magnetic-core memory, performs 229,000 additions or subtractions a second, and multiplies and divides at 39,500 and 32,700 a second.

A year of preliminary research is stored in the 7090. This information covers more than 500 precincts and 75 congressional districts and includes voting records back to 1928 and data on racial, religious, income and residential characteristics of the voters.

Together with early returns, this information will permit computer output on mathematical odds on candidates and instantaneous depth analysis of various trends effecting returns.

As for the National Broadcasting Company, returns will be fed from the company's election center at Rockefeller Plaza to the RCA service center on Wall Street. The 501, introduced in December 1958, is a medium-sized workhorse in processing paper work for big and small firms.

It was later supplemented by the 301 and 601. The Wall Street installation serves the business firms in the New York financial district and will analyze returns in much the same manner that it analyzes business information.

DaSpan, RCA's digital communications system designed to handle as many as 1,200 messages an hour, will be tested by feeding election night returns into the 501 system.

Processing of election returns by the giant computers is unique in application, but not in methodology. However, the work in setting up the statistical probabilities, and the analysis done with election returns and background information, will aid similar work in marketing where projections and analysis must be made from statistical samples.

Election computing also gives some idea of the occupational manpower needed to set up and maintain a system for similar operations.

Preparation of the IBM-CBS program required 60 mathematician man-months, 16 systems—people man-months, and a full-time project coordinator.

On election night, IBM will have about 75 people in the CBS studio, including key punchers, messengers, mathematicians. About 50 more people will be required at the 7090 site, and CBS will have at least another 150 people on deck.

FCC Studies Stereo Broadcast Report

All summer long top industry engineers worked on a crash basis testing six proposed systems for compatible f-m stereophonic broadcasting. Now, here's a quick rundown on what their report says

PROGRAM MATERIAL FOR OFF-AIR STEREO RECORDING TESTS

Pathetique Symphony No. 6 in B Minor by Tchaikovski 3rd movement, last 2 minutes	Boston Symphony, Pierre Monteux
Sonata by Mendelssohn 2nd movement, first 2 minutes	Kurt Rapf
A Foggy Day first 2 minutes	Dorothy Donegan
Arab Dance by Tchaikovski first 2 minutes	Paris Theater Orchestra, Henri Gasto
Classical Symphony by Prokofiev 1st movement, first 2 minutes	Netherlands Phil. Orchestra, Walter Goehr
Misirlou first 2 minutes	Jack Burger
Concerto for Two Violins in D minor by Bach 1st movement, first 2 minutes	Hamburg Chamber Orchestra Gawriloff & Wuehrer
You're an Old Smoothie first 2 minutes	Ray Conniff singers
Second Piano Concerto by Rachmaninoff 1st movement, first 2 minutes	Chicago Symphony Rubenstein
Surrey With the Fringe on Top first 2 minutes	Sauter-Finegan Orchestra
Imagination first 2 minutes	Maynard Ferguson Jazz Band
SPARES	
Winter Wonderland first 2 minutes	Tom & Jerry Vincent
Where or When first 2 minutes	Duke Ellington

By JOHN M. CARROLL,
Managing Editor

THIS WEEK the Federal Communications Commission is mulling over a five-inch-thick, nine-pound document delivered by Panel 5 of the National Stereophonic Radio Committee. It contains field test data on six proposed systems for compatible f-m stereophonic broadcasting. The report will help FCC set standards for f-m stereo. Broadcasters, radio manufacturers and radio rule-making bodies abroad are eagerly awaiting the result.

Compatible stereo implies two things: only one carrier is required to transmit both left and right stereo channels and acceptable monophonic reception is possible by tuning in only the main f-m channel.

The NSRC was formed early in 1959 under auspices of the Electronic Industries Association to furnish information on stereo systems to the FCC (ELECTRONICS, p 26, Jan. 30, 1959). The committee consisted of six panels dealing with systems specifications, interconnection facilities, broadcast transmitters, broadcast receivers, field testing and subjective factors. Activities of NSRC were suspended in Spring of 1960 (ELECTRONICS, p 63, Mar. 11). Meanwhile eight proposed stereo systems had been designated for field testing. In May 1960, Panel 5 was organized to do the field testing (ELECTRONICS, p 48, June 3).

Of the eight systems designated, one proposed by Philco and one proposed by General Electric were withdrawn by their proponents. Systems proposed by Crosby-Teletronics, Calbest Electronics, Multiplex Development Corp., EMI Electronics of England, Zenith Radio and GE were field tested. Field tests involved 36 engineers representing 23 companies and the FCC.

The field tests were conducted in Uniontown, Pa., during July 1960. The transmitter used belonged to KDKA-FM, Pittsburgh. Uniontown is located in a bowl-shaped depression amid rugged terrain some 40 miles southeast of the transmitter.

KDKA-FM operates on 92.9 Mc using a 10-Kw transmitter. It radiates 47 Kw effective radiated power from a six-bay antenna 890 ft above average terrain. KDKA-FM uses a 67-Kc subcarrier for Subsidiary Communications Authorization.

At the receiving site, data was taken on frequency response, distortion, separation, crosstalk and signal-to-noise ratio. These tests were made by transmitting pure tones. At the transmitter, spectrum photographs were taken with a panoramic adapter. The tests also entailed making off-air recordings for each system of stereophonic program material developed by NSRC Panel 6.

Electronic Industries Association is careful to point out that the report of Panel 5 by no means constitutes an endorsement of any system. The Panel makes it clear that in such an extensive series of field measurements some irregularities of instrumentation and measurement are bound to occur and refers readers of its report to an appendix containing comments by systems proponents. However, some general ideas of the state of the art of f-m stereo broadcasting can be gained from the 46 curves.

Frequency response to pure tones was measured in decibels below a 400-cps reference. The transmitter modulation level was independent of frequency (no preemphasis). The

TECHNICAL CHARACTERISTICS OF SYSTEMS FIELD TESTED*

NSRC Number	Proponent	Main Channel Modulation	Subchannel Modulation	Audio Response Subchannel	Deviation, 100% Mod of Subcarrier	Mod of Main by Subcarrier	Subchannel Modulation Method
1	Crosby	L+R	L−R	15 Kc	±25 Kc	50%	f-m
2A	Calbest	L+R	R	8 Kc	±9.5 Kc	15–20%	f-m
2B	Multiplex Dev.	L−½R	R−½L	8 Kc	±9.5 Kc	15–20%	f-m
3	EMI	L+R	directional signal	100 cps	±500 cps	10%	f-m
4	Zenith	L+R	L−R	15 Kc	.....	6.3%	a-m, suppressed carrier
4A	GE	L+R	L−R	15 Kc	.....	10%	a-m

* Source: FCC Docket No. 13506

3-db-down point of proponents of left and right stereo channels ranged from 800 to 3,000 cps. Several systems clustered in the 2,000 to 3,000-cps range. At the 6-db point the range was from 1,400 to 5,000 cps with several systems clustered around 3,500 to 5,000 cps. In general, frequency response followed the 75-microsecond receiver de-emphasis curve.

Distortion was measured with equipment that measured all residual circuit noise as distortion. With the transmitter modulated 100 percent with L (left) equal to R (right), distortion ranged from ½ to 4 percent up to about 7,000 cps. There was much higher distortion for some systems at higher frequencies.

Separation of left and right stereo channels was determined by transmitting an R-only signal and using the output of the R channel as reference, then measuring the L channel output in db below the right and conversely. In the range 300 to 3,000 cps, separation averaged 25 db with less separation at higher and lower frequencies.

Crosstalk was measured in db below the maximum signal that could appear in the disturbed channel. Crosstalk into the monophonic channel with 100-percent modulation on the SCA subchannel averaged 60 db down. Crosstalk into the left and right stereo channels with 100-percent modulation on the SCA averaged 40 db. Crosstalk into the SCA with 100-percent R = L modulation was about 40 db down with some systems only 30 db down.

The spectrum photographs indicated good performance with respect to out-of-band radiation.

Measurements indicated that signal-to-noise ratios better than 40 db are obtainable with all systems when operated with at least 50 microvolts per meter input. Incidentally, all tone measurements were made at a nominal field strength of 1,000 microvolts per meter. Some off-air recordings were made at lower field-strength levels.

Panel 5 did not make any cochannel or adjacent-channel interference measurements, feeling that this work is most properly carried out under laboratory conditions. Nor was any attempt made to evaluate subjectively the off-air recordings.

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The performance-proven Model ST-100 is an entirely new type of vibration exciter. It virtually does away with "cross talk" ...completely eliminates unwanted output harmonics, structural and flexure resonances...provides an exceptionally linear frequency response that makes possible true conformance to the test specifications.

For complete information and applications data, contact ITT Instruments representative or write for Data File E-1301-1

The ITT Model ST-100 can be easily integrated into your own system design or it can be ordered as part of these complete, self-contained ITT testing systems:

MODEL 1201 VIBRATION TEST SYSTEM

MODEL 1205 VIBRATION AND SHOCK TEST SYSTEM

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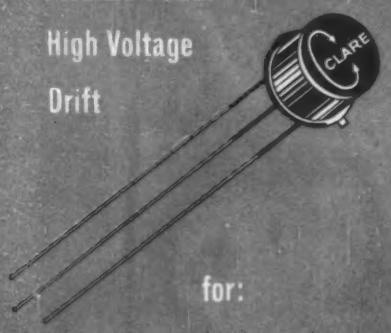

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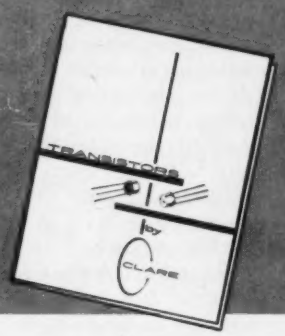

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Railroads Use Electronics To Cut Costs

View of N. Y. Central electronic freight yard shows complex track patterns

SINCE THE END of World War II, U. S. railroads have spent more than $15 billion in capital improvements trying to beat rising operating costs. Electronics features prominently in cost-cutting plans.

Also, several railroads plan to use computers to regulate train operations, route freight cars and process cars through their yards. Many are using closed-circuit television to replace human observers. Railroads are looking to gamma ray detectors, infrared devices and other electronic developments to cut costs.

Here is a specific place electronics is saving railroad money. It's New York Central's "Big Four" classification yard in Avon, some seven miles from Indianapolis. The yard began electronic operations in September of this year. Central now has four automated yards. Several other roads have them too.

A classification yard sorts freight cars by destination and assembles them on outbound tracks.

It cost $11 million to revamp the 490-acre installation. Railroad officials say they expect to recoup the investment in three years.

Nerve center of the Big-Four yard is an analog computer built for the Central by General Railway Signal Company, Rochester, N. Y. Given information on incoming freight cars, this computer controls routing from the moment input information is received until the car is coupled to a train.

Here's how it works. A tower operator spots an entering car and assigns its destination by pushing a button indicating a classification track. The car now rolls down a hill leading to the makeup tracks, controlled solely by the computer.

As the car rolls, its length, weight class, rolling characteristics and speed are fed to the computer. Length is found by measuring the time during which the car intersects the beam of a photocell, weight is found by automatic detectors in the tracks. A series of treadles along the tracks checks the car's location, helps the computer determine rollability.

The computer applies a current to the track, derives a resistance depending upon the distance between a moving car and the last standing car in the train being made up. The computer regulates the speed of the moving freight car by activating retarders along some 200 ft of the route. The retarders clamp in on the car wheels.

Speed is determined by a radar operating at 10,525 Mc using a fixed-tuned klystron. Putting out about 70 milliwatts, the radar has a range of some 200 ft. Detectors are placed in the roadbed between the tracks.

The radar output, as well as the other outputs derived from the motion of the freight car, are fed to the computer as d-c voltages. Computer must also take into account variables due to weather. Wind and rain can affect speed.

A freight-car weighing technique in experimental use is expected to produce more exact measurements than pressure devices now used. Gamma radiation is directed at the car and weight is derived from the amount of reflected radiation. The gamma-radiation technique is also used to inspect wooden track ties, poles and other structural units.

Radiation techniques are reportedly saving millions of dollars when applied to engine inspection. Radioactive piston rings are built into diesel locomotives to check on wear. By measuring radioactivity of oil drained from the crankcase, wear is computed rapidly, accurately without taking the engine apart.

An atomic switch lamp that glows for 12 years by its own power is another railroad innovation. The lamps use krypton 85. Early models sold for about $125; revised versions now sell for $400. They operate like fluorescent lighting fixtures.

Electronics for control and communications are helping reduce costs outside the yards, too. Until recently, the typical intercity rail route used four tracks: two lanes for inbound and two for outbound trains. The inner tracks were reserved for fast trains. Freights ran on the outer tracks accessible to sidings. With present-day communications and detection devices, railroads find they can eliminate two tracks in each direction and rely on electronics to tell them the location of each train. Additional switches along the new two-track routes let railroadmen route trains around each other. They get more use now out of two tracks than they did before out of four and save on personnel and real-estate taxes.

Electronics to be West's Largest Employer

Southern California electronics industry is now busy stepping in to support regional economy as the aircraft industry continues to sag

By HAROLD C. HOOD,
Pacific Coast Editor

LOS ANGELES—SOME INDICATIONS of a business downturn have seeped out of southern California in past weeks. These indications seem to be most strongly linked to the aircraft industry. Electronics appears to be holding up well. Here's what local business executives have to say:

An official of the Security First National Bank says he feels the nation is in the early phase of a recession. "And southern California will undoubtedly participate fully in any such recession. Northern California has not been as hard hit because it has not had the aircraft industry to pull it down. Airframe people have been losing 2,500 employees a month. Electronics is the one bright spot".

The L. A. Chamber of Commerce and the State Dept. of Employment reinforce the aircraft picture, point hopefully to electronics. Aircraft was hit by cancellation of the F-108 and B-70 programs late in '59, but aircraft employment had been on the decrease since spring of '57 when it achieved a high of 222,500. Last year it slipped to 180,000, and is now 143,000.

During this period, electronics employment in L. A. and Orange County swelled from 75,000 to 120,000, says the Chamber of Commerce. From December '59 to May '60 it slacked off by 2,000, but more than recouped this loss by expanding at a rate of 1,000 new people each month to its present all-time high.

James Lewis, research director for L. A.'s Chamber, says "southern California has not suffered businesswise as much as other predominantly aircraft-oriented sections because of the area's strong electronics base. This new industry has taken up much of the slack left by airframe layoffs, and will soon be our number one employer."

Hugh Moore, chairman of Lerco Electronics, points out that business in our industry as a whole is about even with last year, but that it has not increased as expected.

Moore also said that placement of military contracts has accelerated in recent months, but that this has not been taking place on a scale sufficient to touch off boom conditions.

One board chairman in the components business is frankly worried about some of his customers. "I've never seen so many companies in financial difficulty of one kind or another as right now. People are slow paying their bills and the "past-due" list is longer than I've ever seen it. There have been several bankruptcies and an increasing number of small outfits have made themselves available to larger companies by the merger route."

Most businessmen deny that Wall Street's ills are a major cause of the present business slow-down. But one who feels otherwise is a spokesman for the Birtcher Corp., manufacturer of medical electronics equipment. "Most doctors play the stock market," he points out, "and when things are rosy, their sales resistance is low. Right now, they just aren't buying anything extra, and our sales are suffering".

On the rosier side, Neeley Enterprises, electronics reps, reports a recent pick-up in sales. "If it never gets worse than this it'll be wonderful," quips Bob Boniface, vice president. "We've noticed some people have been hurt on individual military programs, but overall the business atmosphere is healthy. The main trouble appears to be that people aren't getting funded on some of their working capital. However, as this funding rate increases over the next quarter, I think this will show up in increased spending, and will help some of the little fellows who have been suffering.

"Also, some industries that have been considering electronic installations have been hit hard recently, the oil industry for example, and are postponing additional capital outlay at this time. We've also heard some components people complain that many of the military programs they've been supplying are well in the mill, and that contractors are stocked up on parts."

For president Donald Duncan of Duncan Electronics Corp. in Santa Ana, recently back from the east with a pocket full of orders, there has been no gloom. "I don't think southern California has suffered as much as some other areas, notably around New York. The slump appears to have started earlier back there, sometime during the spring. Out here you never heard people talking about it until just before Wescon.

James Parry, vice president of the American Marketing Association, says: "Defense contracts are getting larger, but there will be fewer of them. Some primes of the past will be subcontractors of the future and they're not happy about it."

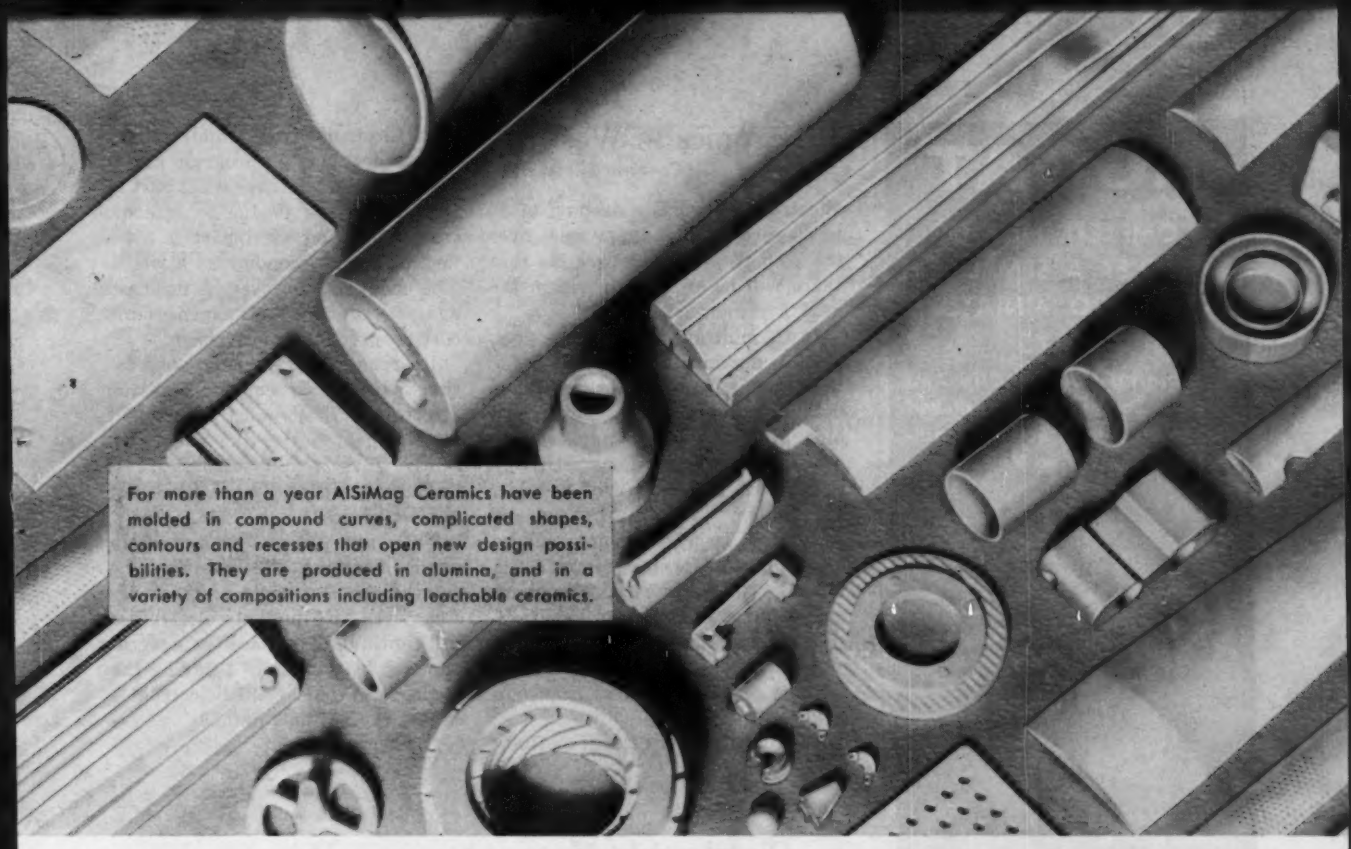
An executive of Packard-Bell

(Continued on p 38)

Infrared Phone

Communications device developed by Infrared Industries, Inc., uses infrared radiation as voice carrier

CIRCLE 37 ON READER SERVICE CARD→



For more than a year AlSiMag Ceramics have been molded in compound curves, complicated shapes, contours and recesses that open new design possibilities. They are produced in alumina, and in a variety of compositions including leachable ceramics.

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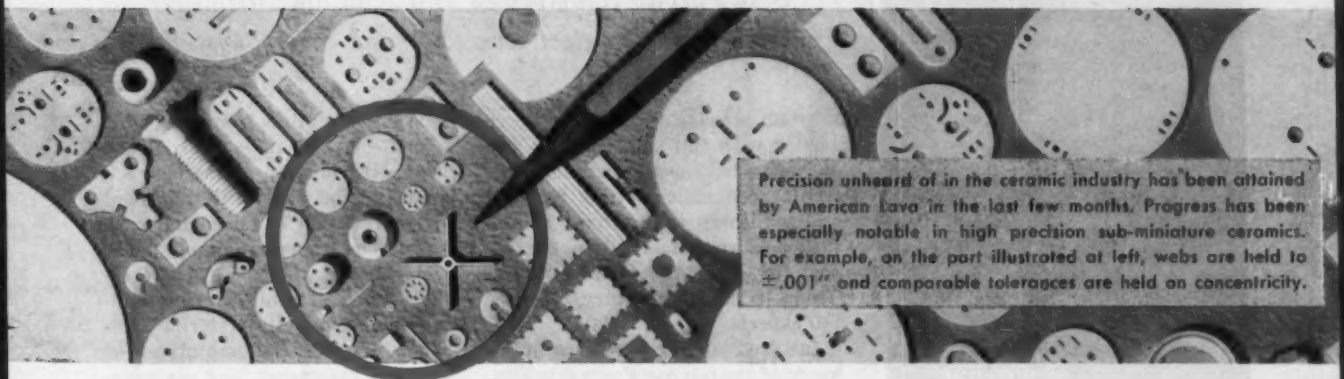

Precision unheard of in the ceramic industry has been attained by American Lava in the last few months. Progress has been especially notable in high precision sub-miniature ceramics. For example, on the part illustrated at left, webs are held to ±.001" and comparable tolerances are held on concentricity.

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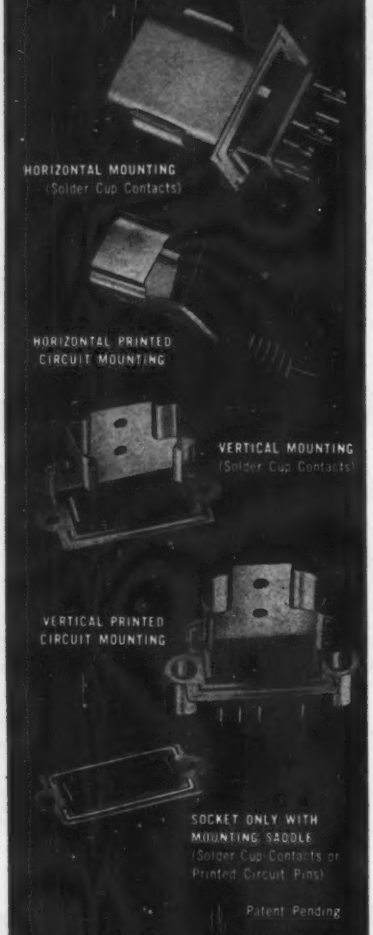

These assemblies will accomodate Micro-Miniature relays as manufactured by G. E., Elgin, Sigma, Allied, Potter & Brumfield, Clare, Iron Fireman, Babcock and many others.

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Electronics in West . . .

(Continued from p 36)

Electronics reports a drop-off of 20 to 40 percent in radio-tv sales over the past 90 days, but predicts that there will be an upturn within the next five months.

In the military business, he says, small companies are screaming for their money as they never have before. "Competitive advertised bids are being more aggressively sought, and are more competitively priced than I've ever seen" he adds.

President Frank Deluca of Acoustica Associates points out he has found California a more fertile territory than the east. "Company management out here is generally younger, and more receptive to new ideas. Our western operations have felt the recent pinch less than our east coast branch."

H. L. Hoffman, president of Hoffman Electronics, says his company is on a cost-cutting program and is attempting to discover what part of increased costs is due to internal inefficiency and what part is a reflection of the economy as a whole. The company, however, is dead set against reducing R&D expenses and cost of product improvement.

In rebuttal to gloomy observations, Harry Greenfield, research director of Electronics Investment Management Corp., San Diego, recently gave a talk before L. A. Chamber entitled "What Shakeout in Electronics?"

Not only are many new companies entering the industry, he pointed out, but most of them are doing well. He predicts electronics will continue to outpace the general economy by 2 or 2½ to 1 during the sixties, and that by 1970 electronics will be the nation's number one industry.

Single Air Force Agency Proposed

Study group recommends unit with authority over present, future electronic command-control systems

BEDFORD, MASS.—A single Air Force agency with full responsibility and authority to overhaul existing electronic command-control systems and to design the systems of the future is recommended in the report of the AF Winter Study Group, a science-military team of 140 experts.

Involved in the report, now in the hands of the top Air Force echelons, are the destinies of the "L" systems, and allocation of some $10 to $15 billion which the Air Force will spend in the 1960's for electronic data and evaluation systems needed by military decision-makers in the framework of a potential global war.

The proposed central agency "would be the AT&T of command-control technology," says a civilian AF scientist. "There's no holding company in the country big enough to integrate the command-control systems.

"That will be the job of this central agency. It will spell out what the Air Force wants from industry."

In effect, the Winter Study Group ratifies the mission of the new AF Command and Control Development Division (C^2D^2), headquartered here at The Hanscom Complex. The Complex at Hanscom Field also includes the Electronic Systems Center, which is an Air Material Command function, representatives of operating commands, and engineering support from MITRE Corp., MIT Lincoln Laboratory and AF Cambridge Research Labs.

Integration of the command-control mission is necessary to meet a "crisis in command," says Maj. Gen. Kenneth P. Bergquist, C^2D^2 commander. The crisis is imposed by revolutionary advances in the destructive power of weapons, speed and range of delivery systems, the extreme quantity and abstract quality of data, the compression of decision time, and the necessity for rigid control to avoid "war by accident."

The real problem, says Gen.

Bergquist, is not acquiring mechanized equipment but how to control the aerospace force.

Here is what the report means to electronic primes, subs and components people:

1. Crash emphasis on some "families" of "L" systems, notably in the command area: SACCS (465-L), AFCS (473-L) and NORAD COC (425-L). The Strategic Air Command and Control System is considered most urgent, is the only one of this trio which now has any hardware. Plans for the NORAD Combat Operations Center will be radically overhauled for further integration, compatibility with the command-control complex.

2. A long, hard look at existing control-area systems such as SAGE (416-L) and AWCS (412-L) to make sure further expenditures are worthwhile; also to find auxiliary uses for them, such as SAGE for Air Traffic Control; at the same time bearing in mind that manned bombers and other air-breathing vehicles still pose a threat, even in the age of missiles.

3. Emphasis on integration of the sensor systems and making them compatible inputs for the decision-making process. This family includes the DEW's, BMEWS, ELMINT (466-L), IDHS (438-L), and nuclear detection systems. Of particular importance is thorough integration of SAMOS and MIDAS into this sensor-intelligence-warning network.

4. Integration also of the support systems such as weather (433-L) and global communications (480-L) into the evaluation and command decision process.

5. "Invasion" of the military command environment by electronic design men and other technical experts. Many a military tradition will go by the board, because the decision-making military commander will depend on an electronics machine standing next to him and on a man who can "talk with the machine."

6. Air Force recruitment—for all officer ranks—of men skilled in electronics, data-processing, programming, the newly emerging command-center technology, which is essentially military automation, heavily rooted in electronics.

Engineering notes from the **SM/I REPORTER**

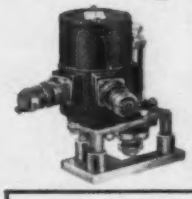
BY STANLEY M. INGERSOLL, *Capabilities Engineer*

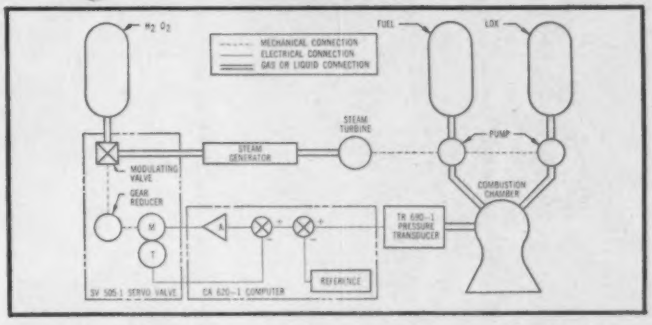
Report No. 13
Type CC 506 Thrust Control System

Designed for tactical artillery weapons, this system maintains the thrust levels of liquid propellant rocket engines at specified magnitudes. Its sensitive SM/I-designed pressure transducer measures combustion chamber pressure and is statically and dynamically accurate even in the extreme shock and vibration environments of the missile. When the transducer detects a deviation from the pre-set reference pressure, it generates an error signal. This signal is amplified and transmitted to a servo controlled valve which restores the pressure to the proper setting. The amplitude of the signal is proportionate to the magnitude of pressure change. Heart of the transducer is a unique, SM/I-developed twisted Bourdon tube that combines high pressure sensitivity (rotational movement) and low acceleration and vibrational sensitivity (linear movement). A 300 PSI unit has only a .2% error under 15 g's vibration and 10 g's acceleration and withstands 20 g's shock without disturbing its setting.

Typical Technical Data

Temperature	−65° to +165°F
Vibration	10-38 cps ±0.25" Double Amplitude. 38 to 2000 cps ±25 g's
Shock	50 g's
Altitude	Sea Level to 200,000 ft.
Weight	10 pounds
Input Voltage	115 volts 400 cycles
Accuracy	better than 1% of the pressure
Valve Flow Rate	30 lb/min H_2O_2
Magnitude of Set Pressure	300-1000 psi
Slewing Speed of Valve	2-3 seconds





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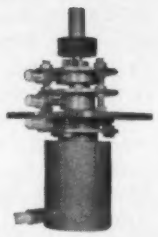

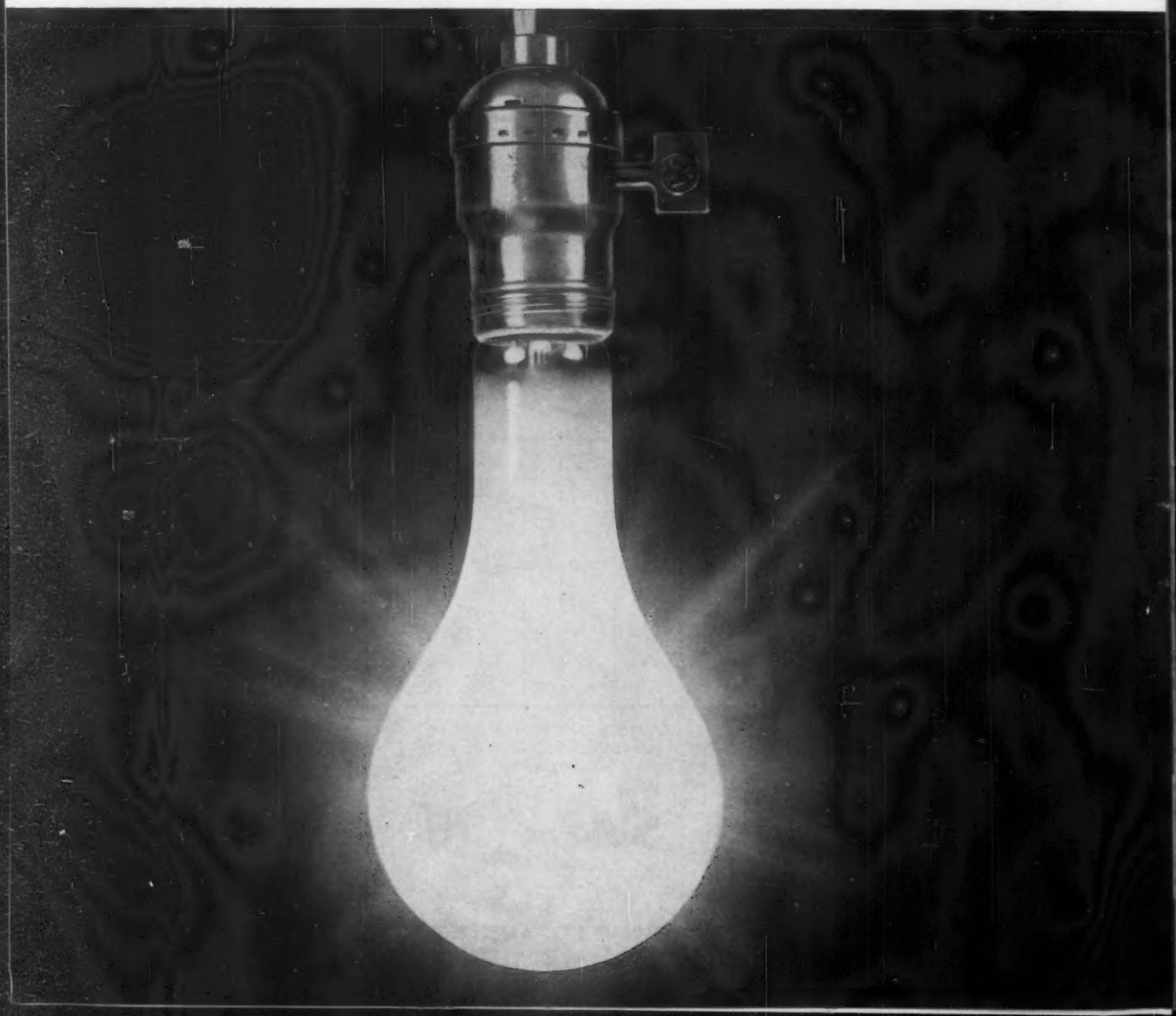

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←CIRCLE 40 ON READER SERVICE CARD

Computers to Aid Data Abstracting

CHICAGO—SPECIALIZED COMPUTERS offer scientists and engineers their best chance of keeping up with the floods of information from rapid advances in modern science and technology, according to Verner Clapp, president of the Washington, D. C., council on library resources.

Clapp described techniques for abstracting information and hardware for retrieving it within milliseconds at the seventh annual Computer Applications Symposium here last week.

The two-day symposium was under the sponsorship of the Armour Research Foundation.

Loglan, a logical language which opens up the possibility of writing computer programs in a common English pseudocode, compiling them automatically, then debugging them by voice commands, was described by J. C. Brown of University of Florida. Loglan may extend the possibility of having the computer talk back to, and advise, the program, may be able to interpret a single sentence in more than one way.

Cobol, a business-oriented automatic code, was described by John L. Jones of Wright-Patterson AFB. Observations on experience with Algol, a mathematical pseudocode, were outlined by John G. Herriot, Stanford Computation Center.

Engineering and scientific applications described during the conference included weather forecasting for the Navy, design of an optical lens system for the Los Alamos Scientific Laboratory, and long-range data communications by telephone, teleprinter, microwave for AT&T.

Computer predictions of highs and lows in the national economy for the Federal Reserve system were discussed during the opening-day program on business applications. The opening sessions also covered processing of subscription records for a magazine, controlling operations of a mail-order house, and solving accounting problems for a brokerage firm.

Package Sorter Cuts Labor Costs

European mail-order executives inspect computer-linked package-sorting conveyor installed by Speaker Sortation Systems in a Milwaukee plant

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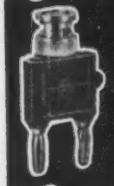

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University Gets Giant Computer

UNIVERSITY OF CALIFORNIA, which operates the Lawrence Radiation Laboratory, Livermore, Calif., for the Atomic Energy Commission, has accepted the first Larc computer system. Larc was designed and built by Remington Rand Univac, will attack problems in nuclear science and technology applicable to the nation's weapons program. Larc is actually two computers, one slaved to the other, and is capable of performing a quarter-million operations a second.

Rutgers University lists and discusses its 1959-60 research projects in the recent report of the Bureau of Engineering Research, published by the university's Engineering School. Among projects described:

Electronic torch crystal-growing technique that replaces the conventional verneuil-type oxyhydrogen burners with an r-f generator. Proper arrangement of coaxial connectors produces a sustained electrical discharge from a single electrode. This discharge causes the dissociation of a polyatomic gas, which on subsequent recombination provides a high-temperature medium.

Development of a torquemeter which will continuously indicate torque in a rotating shaft, while not physically connected to the shaft. Frequency and phase-angle transmission across an air gap is the method used.

Arlington State College in Ft. Worth, Tex., is host to a series of seven weekly lectures on semiconductor theory and technology; the series started Oct. 18. Members of Texas Instruments' technical staff are conducting the lectures, which are open to scientists and engineers of the north Texas area as well as students. Sponsors are the Ft. Worth section of the Institute of Radio Engineers and the student IRE group at Arlington. Three of the lectures are on semiconductor theory, three on applications of semiconductor devices, and one on present semiconductor accomplishments and possible future developments. Professor S. T. Lanahan of Arlington is coordinating the series.

University of Pennsylvania was the recipient of a $1-million grant from the National Science Foundation for the purchase of a 12-million-electron-volt tandem accelerator for use in low-energy nuclear physics research. Neighboring institutions will also have use of the equipment, says president Gaylord P. Harnwell. Low-energy research is concerned with the arrangement of nuclear particles and the forces in the nuclear structure.

University of California viniculturist H. P. Olmo has produced an improved variety of grape by irradiating vines with X-rays. He cut buds off a dormant vine, exposed them to 2,500 roentgens, then grafted them onto older stock for quick fruiting. Among varieties produced was one that had loose-clustered fruit, giving the grapes high commercial value.

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Picture enables operator to boresight tack rivets used as tape-to-panel synchronizing points when Drivmatic Riveter at Douglas Aircraft is operating automatically

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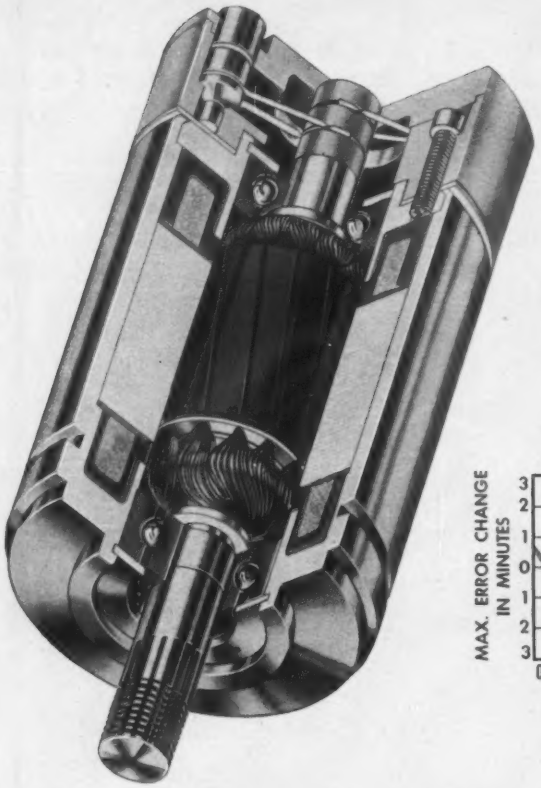

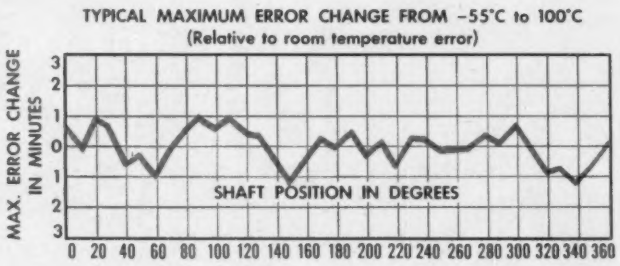
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(Relative to room temperature error)
MAX. ERROR CHANGE IN MINUTES
3
2
1
0
1
2
3
SHAFT POSITION IN DEGREES
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MEETINGS AHEAD

Nov. 4: Automatic Data Processing Systems, Institute of Electronics In Management; American Univ., Washington, D. C.

Nov. 4-5: Communication Symposium, Montreal Section; Queen Elizabeth Hotel, Montreal, Canada.

Nov. 14-17: Magnetism & Magnetic Materials, AIEE, AIP, ONR, IRE, AIME; Hotel New Yorker, New York City.

Nov. 14-16: Mid-American Elect. Convention, MAECON; Hotel Muehlebach, Kansas City, Mo.

Nov. 15: Product Engineering & Production, PGPEP of IRE; Contact D. Ehrenpreis, 325 Spring Street, New York City.

Nov. 15-16: Northeast Electronics Research & Engineering Meeting, NEREM, PGPT of IRE; Commonwealth Armory, Boston.

Nov. 15-16: Engineering Application of Probability & Random Function Theory, PGIT of IRE; Purdue Univ., Lafayette, Ind.

Nov. 20-21: Electro-Optical & Radiation Devices, PGED of IRE, AIEE; Stanford Research Inst., Menlo Park, Calif.

Nov. 28-29: National Association of Broadcasters, Fall Conference; Biltmore Hotel, New York City.

Nov. 30-Dec. 2: Electronics Exposition, Long Island Electronics Manufacturers Council; Roosevelt Raceway Exhibit Hall; Westbury, Long Island, N. Y.

Dec. 1-2: Vehicular Communication, Annual Meeting, PGVC of IRE; Sheraton Hotel, Phila.

Dec. 5-7: Electronic Equipment Maintenance, EIA; Hilton Hotel, San Antonio, Texas.

Dec. 5-8: Electrical Insulation, National Conf., AIEE, NEMA; Conrad Hilton Hotel, Chicago.

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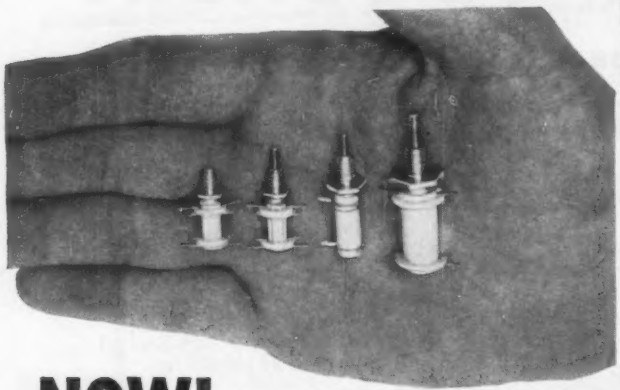

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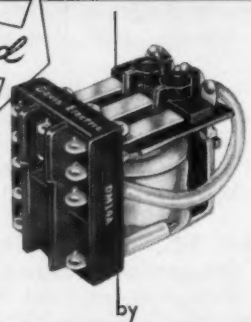
1 to 3 polet, single or double throw—5 or 10 amp.

MOUNTING
6-32 stud, 6-32 tapped hole, or octal plug.

DIMENSIONS
1" wide x 1-9/32" high x 1-13/16" long.



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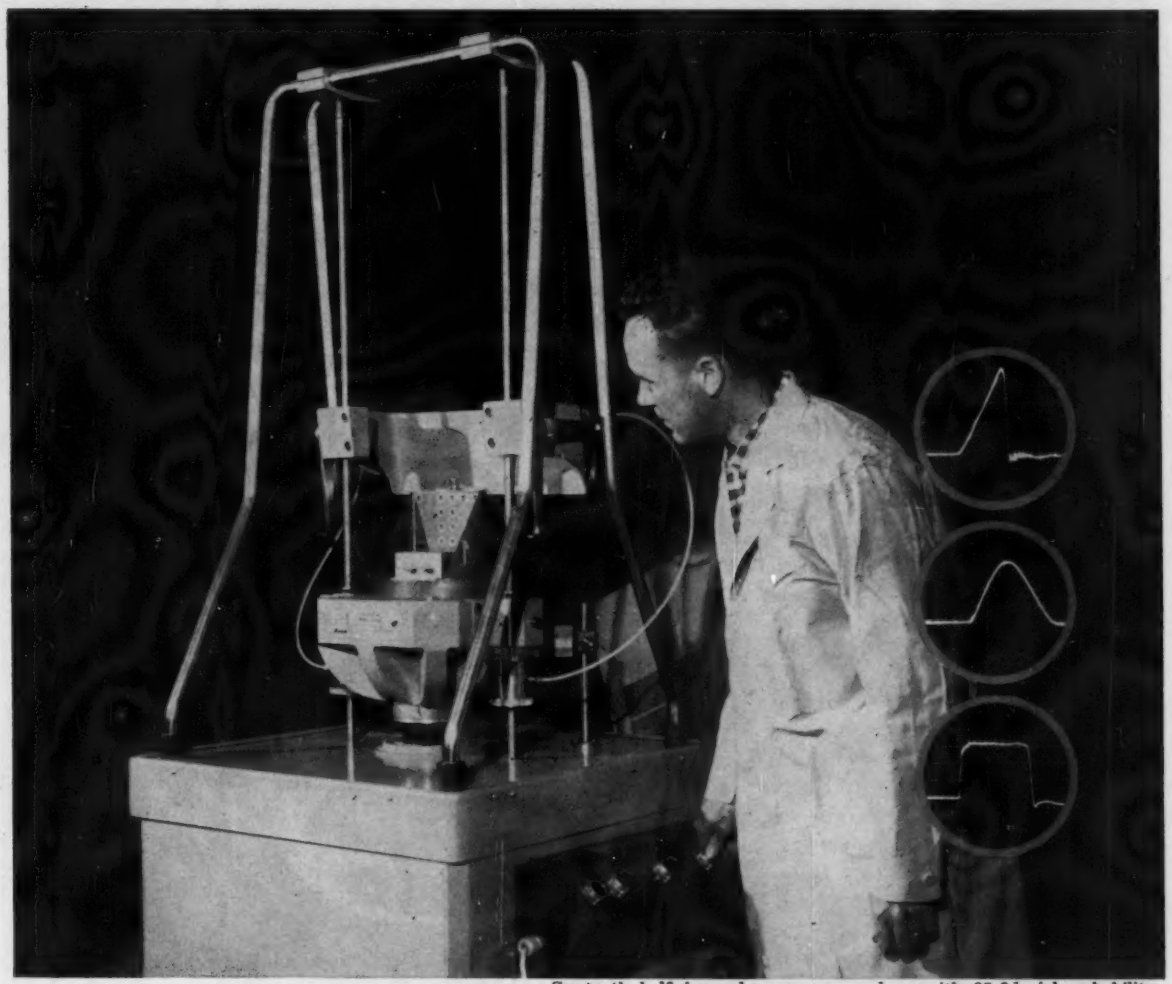

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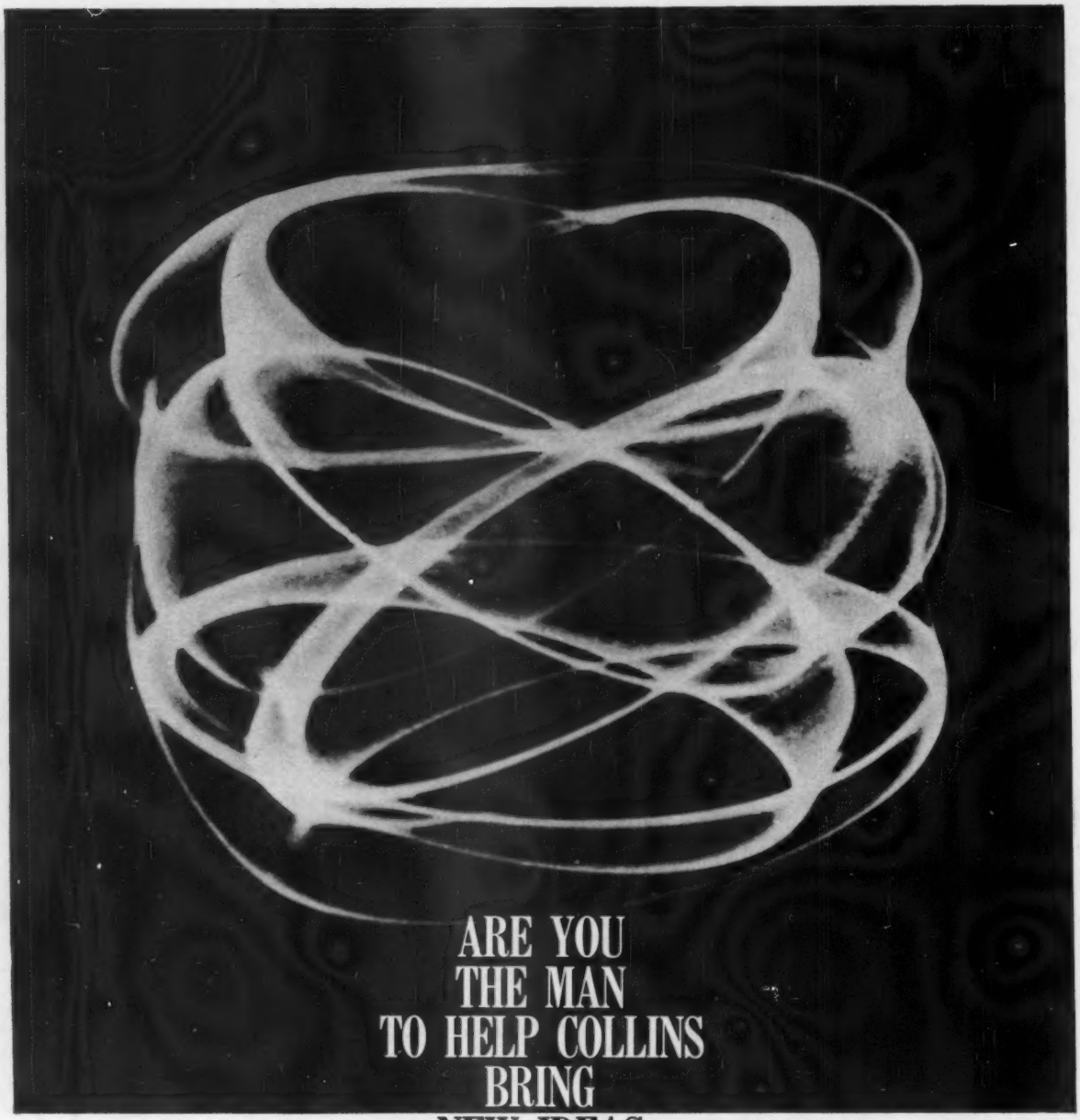

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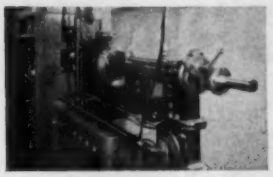
Nuclear Radiation & Electronics:

Just what part does Hughes play?

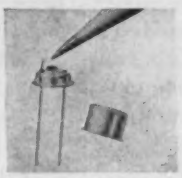
It all started some six years ago. As a leader in military and commercial electronics, Hughes was keenly aware of the vital inter-relation between nuclear technology and electronics technology. ■ The specific question which Hughes engineers sought to answer was, "What are the effects of nuclear radiation on electronic systems?" ■ To answer this question, Hughes brought together leading scientists in both the nuclear and electronics fields. ■ In the process of solving this problem, these scientists and engineers became acutely aware of the need for adequate equipment for radiation generation, measurement and handling. They proceeded to develop these badly needed devices—both to solve their own problems, and to make them commercially available. ■ The linear accelerator is a typical example. The need to accurately simulate the gamma radiation from nuclear detonation was apparent. So, Hughes developed and built the first gamma accelerator with variable pulse widths, a high repetition rate, and a high peak electron beam current (over 1 amp). For more extensive investigation of the nuclear environment, Hughes also builds a pulsed reactor for the simulation of neutron radiation. ■ Radiation detection devices that were faster, more compact, and more versatile were also needed. This problem was solved when Hughes scientists developed an incredibly small (2 mm square) solid state detector with better than 1% resolution and response time of less than 1 nanosecond. ■ Remote handling of highly radioactive objects was another problem examined by Hughes. In designing radiation research facilities for the investigation of nuclear radiation effects, novel applications for proven electronic control techniques were found. One result was the Hughes MOBOT*, a completely remote controlled handling machine using TV vision and electronic controls. ■ So, what part does Hughes play? Hughes specializes in nuclear radiation—analysis of effects, and products for its generation, measurement and handling. If you have a radiation problem, we would like to talk to you about it. Write, wire or call collect: HUGHES NUCLEAR ELECTRONICS LABORATORY, P.O. BOX 90915, LOS ANGELES 45, CALIF., TWX INGL 4036, ORCHARD 0-1515, EXT. 5355.



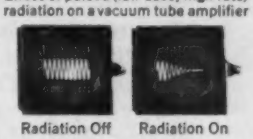
Hughes High-Current Linear Electron Accelerator

Hughes MOBOT Mark I for remote controlled handling

Hughes Solid State Nuclear Radiation Detector



Effect of pulsed (low dose, high rate) radiation on a vacuum tube amplifier



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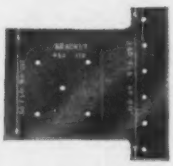
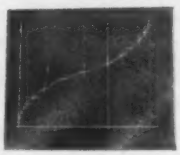
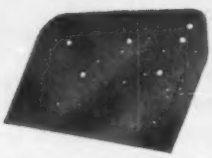


A typical Strippit Flex-O-Drill drilled template.



A typical Strippit Flex-O-Drill scribed layout.



A typical Strippit Flex-O-Drill production piece.

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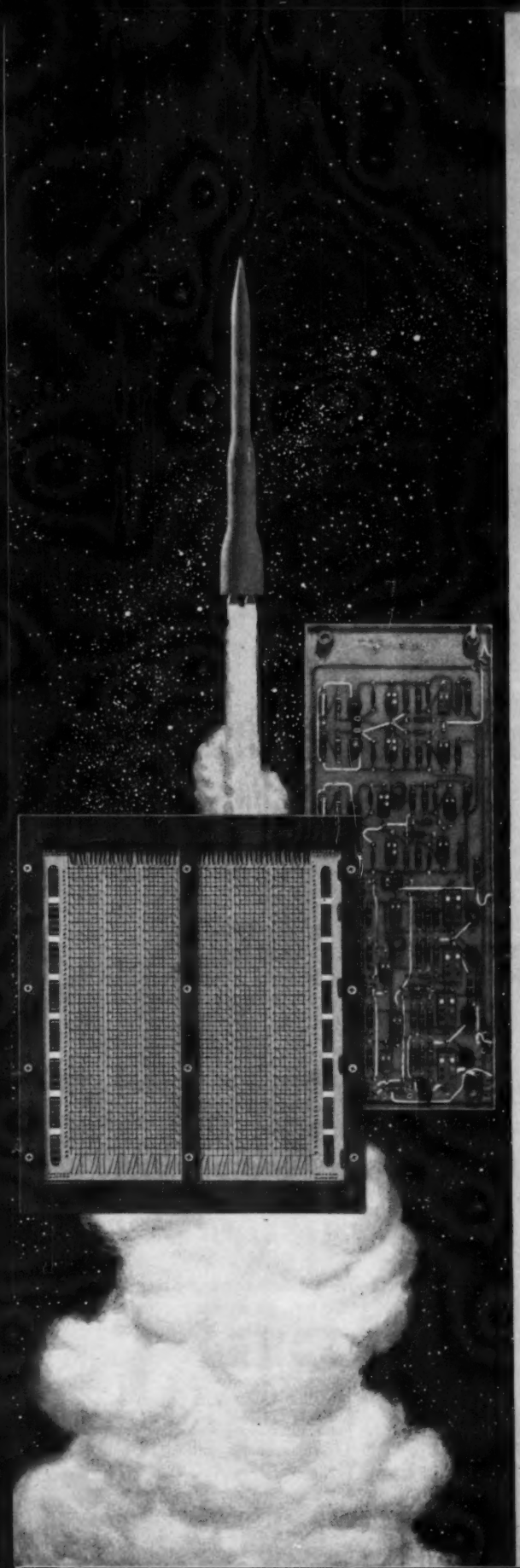

Expanding the Frontiers of Space Technology In

COMPUTER DEVELOPMENT

Space Vehicle Command – An important advance in the control of space vehicles has been accomplished with the development by Lockheed scientists of space-borne, command decoders and sequence programmers. Basically, the programmers store information and, at a predetermined time when the vehicle is out of contact with ground stations, cause commands to be executed by the various subsystems. In this way, versatility of vehicle missions can be markedly expanded.

In addition, when the vehicle comes in range of ground command stations, the programmer can be given new instructions for either future or immediate action. All of the programmer's components are solid state devices. There are no moving parts nor vacuum tubes. The ferrite core memory in which information is stored is a two core-per-bit matrix.

A primary design goal was to reduce power requirements. Although the Lockheed programmer is highly complex and employs over 600 transistors, the average power consumption is only 3.5 watts, less than a Christmas tree light bulb. The development of such complex circuitry that will withstand the shock, vibration and a temperature range from −40°C to +85°C is in itself a significant achievement.

The highly precise timing necessary for the execution of the various programmed assignments is accomplished by means of a crystal oscillator – maintained at an exact temperature by means of a two phase mixture of solid and liquid inert chemical.

Engineers and Scientists: Lockheed's capability in design and development of computers is contributing to the advancement of the state of the art in a number of areas. Work is being carried on in research and development of ultra reliable digital circuitry, ferrite logic systems, and millimicrosecond switching techniques; radically new devices for pattern recognition operations; high speed digital plotters; self-organizing systems; large scale systems for the automatic storage and retrieval of information; microminiature packaging techniques; and systems research and engineering of large scale information handling complexes.

If you are experienced in work related to logical design or computer development, you are invited to inquire into the interesting work being conducted and planned at Lockheed. Write: Research and Development Staff, Dept. K-22, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense industrial security clearance required.

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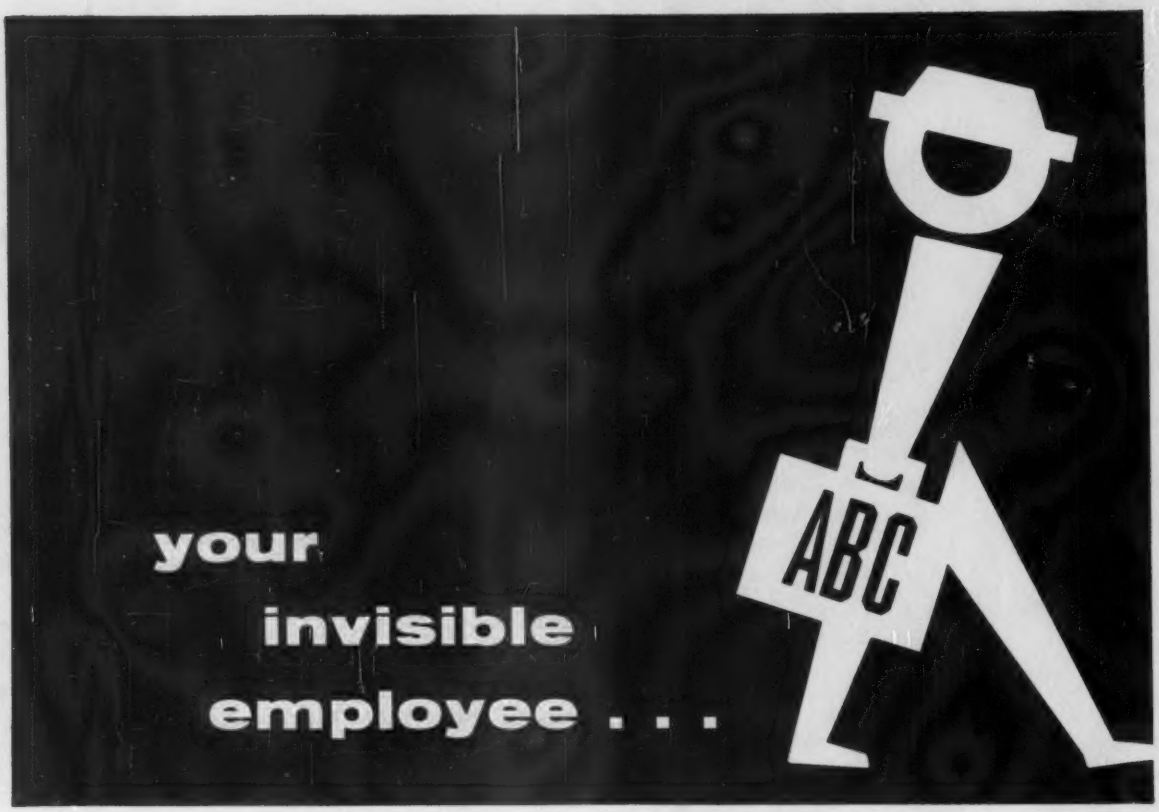

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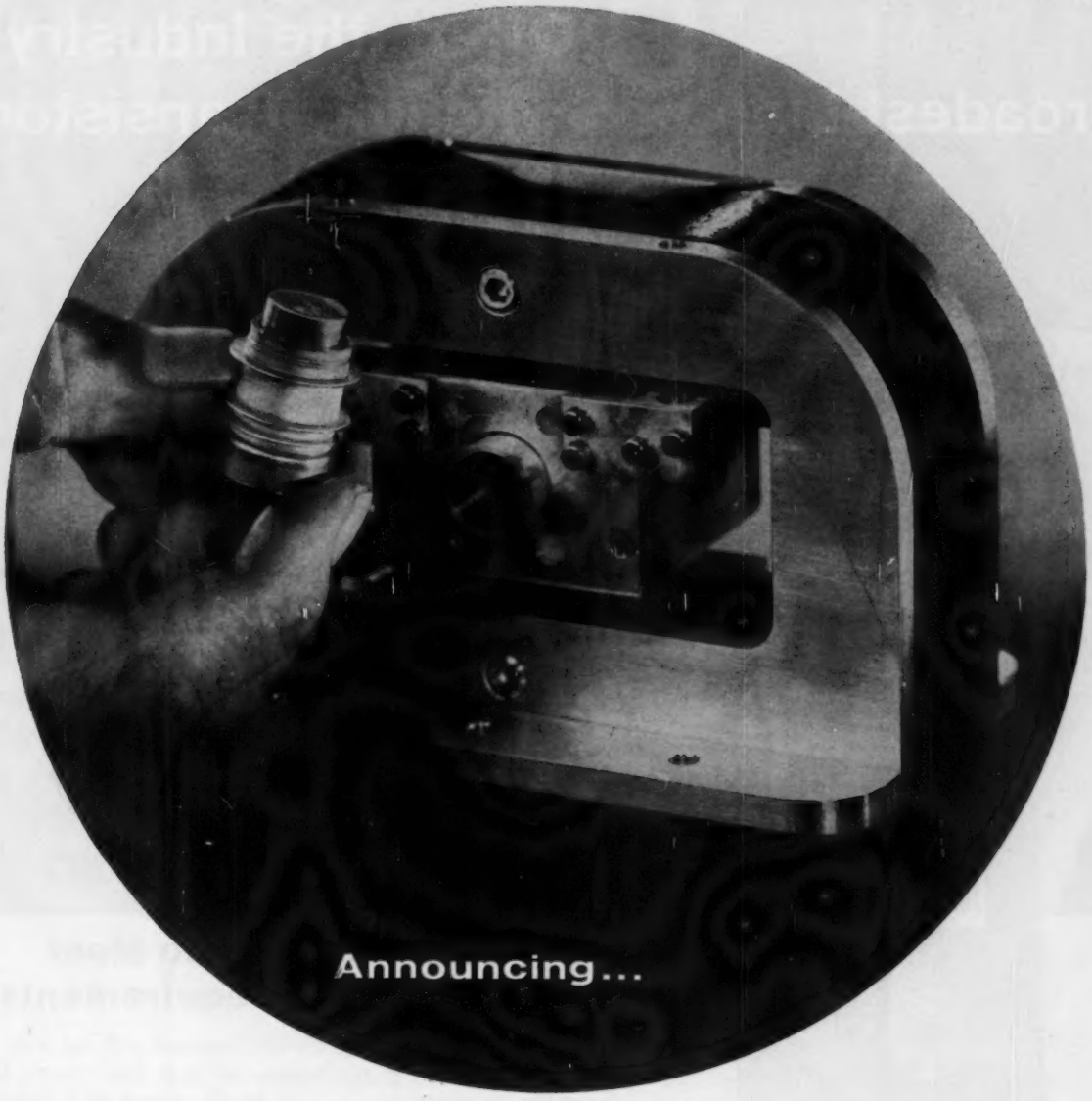

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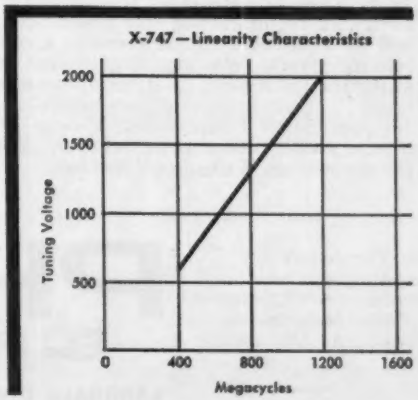

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electronics
November 4, 1960

FIG. 1—Scale model tank and transmitter simulates operation of actual medium tank. Tank cannon houses light-beam gun used to kill other tanks

Radio-Controlled Tank for Realistic Combat Training

Tank platoon training device uses multichannel tone-operated radio control system to maneuver scale models of medium tanks over scale terrain in simulated combat exercises

By R. A. BAKER,
Senior Staff Scientist,
U. S. Army Armor Human Research Unit,
Fort Knox, Kentucky

CONSIDERING the high cost of ammunition, gasoline tank maintenance and the extensiveness of terrain that would be required for maneuvering full-size tanks, an inexpensive way had to be found to conduct realistic combat training for U. S. Army tank platoons.

Historically, this is not a new problem. The dilemma of limited funds and inadequate maneuver space is as old as the Army. Some past attempts to overcome this problem of tank maneuvers have been fairly successful. One of the most successful was the World War II use of the Haskell War Map—a large horizontal display simulating the tactical movements of combat units. Since this technique appeared to have training value, it was decided to adapt it for training tank platoon personnel.

The possibility of conducting normal combat exercises indoors on a reduced scale not only appeared feasible but also relatively easy to carry out in a realistic manner. Work was begun on a miniature armor battlefield using scale models.

The major problem was the development of small scale equipment that would have the same characteristics as the tank equipment that would be used in combat. The miniature remote-controlled tank shown in Fig. 1 is a 1:25 scale model of the M48A2 medium tank used by the U. S. Army.

The radio-control transmitter and receiver units operate in the 27 Mc radio band and provide eight tone channels for command signals to the tank. The radio-control

transmitter of Fig. 1 consists of two portions: tank control and fire control. The larger unit houses the actual transmitter and provides controls to be operated by the tank driver. With these controls, the driver can drive the tank forward or reverse and can steer the tank to the right or left.

The smaller unit is used by the tank gunner and with it he can control operation of the tank turret and gun in azimuth and elevation angle. Another control permits firing the tank light-beam gun.

The transmitter, shown in Fig. 2, consists of crystal-controlled oscillator-multiplier V_1 driving power amplifier V_5. Grid modulation of the power amplifier is used to keep audio power requirements low. The transmitter uses battery-powered tubes and delivers approximately 0.25 watt into a 60-inch base-loaded whip antenna.

The audio section consists of phase-shift oscillators V_3 and V_4 and a common modulator tube V_2. Both audio oscillators can be operated simultaneously if desired and mixing takes place in the grid circuit of the modulator.

Each audio oscillator is of the phase-shift type. As shown in the simplified schematic of Fig. 3, only two sections of a phase-shifting network are used with a variable inductor in each plate load providing the additional required phase shift.

When control switch S_1 is operated to transmit a command, one portion of the switch applies plate voltage to the audio oscillator while the other portion introduces the center leg of the phase-shift network. The particular audio frequency is determined by setting of potentiometer R_2 or R_4 in conjunction with its limiting resistor R_1 or R_3. Control switch is arranged so that only one tone can be generated at a time in each oscillator. When the switch is in its center (neutral) position, plate voltage is removed from the audio oscillator.

The variable inductor plate loads can be turned to adjust the center frequency of its oscillator. The output of both oscillators are coupled to the control grid of the modulator tube which in turn grid modulates the final r-f amplifier.

The receiver is a transistorized superheterodyne using a crystal-controlled local oscillator. As shown in Fig. 4, surface-barrier type transistors are used in the r-f portion of the receiver.

This type of transistor is used because it will operate at low collector voltages, provide usable gain with a minimum number of stages, has low internal capacitance and requires no neutralization.

The audio transistors used have high beta at low voltages and have good power ratings. A short antenna directly coupled to the mixer coil provides a good match to the receiver.

To obtain the required selectivity, four tuned circuits are used with the first three decoupled from the last one for stability. By using a collector-type detector additional gain was obtained.

Automatic gain control is accomplished by using the diode action of each i-f amplifier since they act as collector-type detectors whose load is a resistance in their base circuits. Since the agc operates at high levels, the last i-f amplifier agc operates first. By the time it has reached saturation, the preceding if-stage agc begins to function.

The audio output is developed across the coil of a resonant-reed relay. Each reed is tuned to a different audio frequency between 250 and 500 cps. Each reed activates an individual transistor switch which in turn energizes a relay to supply power to the circuit under command.

Receiver selectivity is 6 db down at the 10 Kc points and 80 db down at the 50 Kc points. The sensitivity is 5 μv for 4 v peak-to-peak across the coil of the resonant-reed relay and the i-f frequency is 455 Kc.

Photoelectric cells are mounted on each side of the tank just under the support rollers. This is the most vulnerable point for most

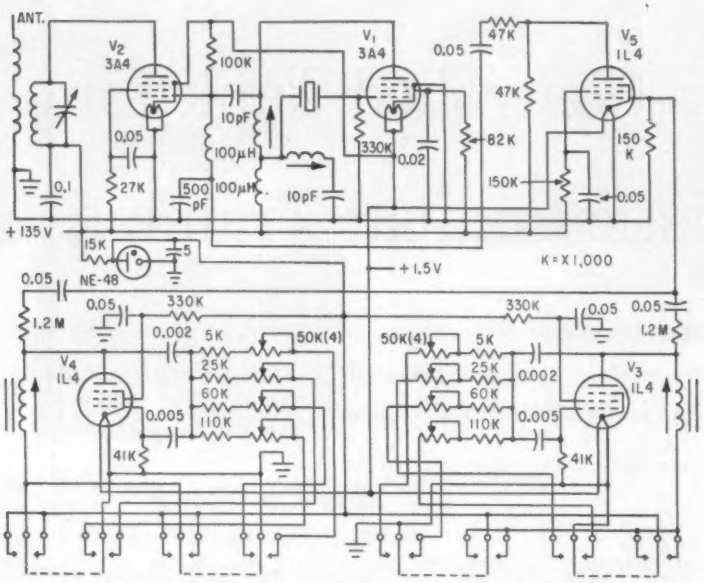


FIG. 2—Two simultaneous tone channels can be transmitted to the tank. Transmitter operates at 27 Mc with 0.25-watt output

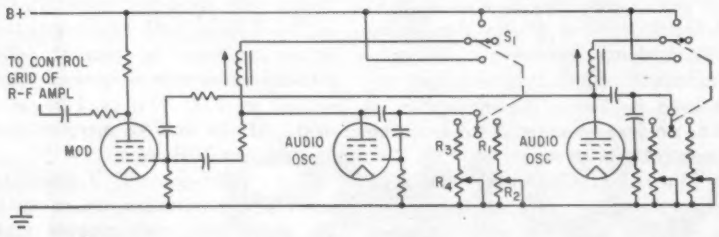


FIG. 3—Tone generator uses center leg of phase shift network to change tone frequency. Plate inductor sets center frequency

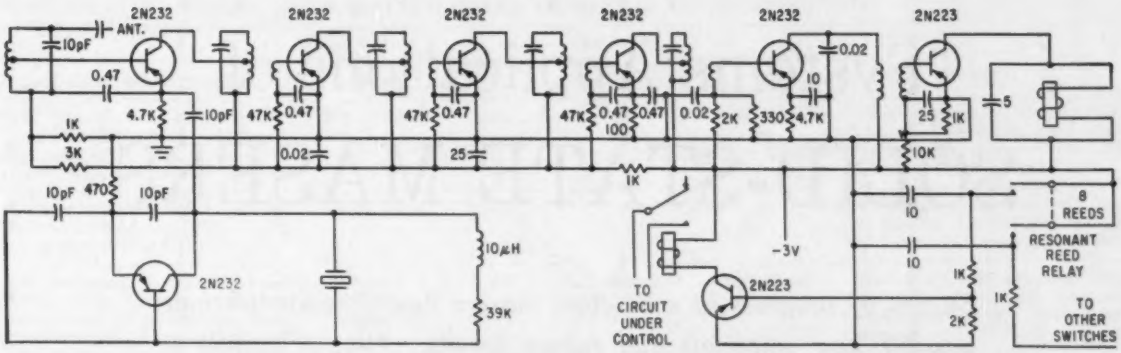


FIG. 4—Receiver energizes an eight-reed resonant-reed relay with each reed activating its own transistor switch

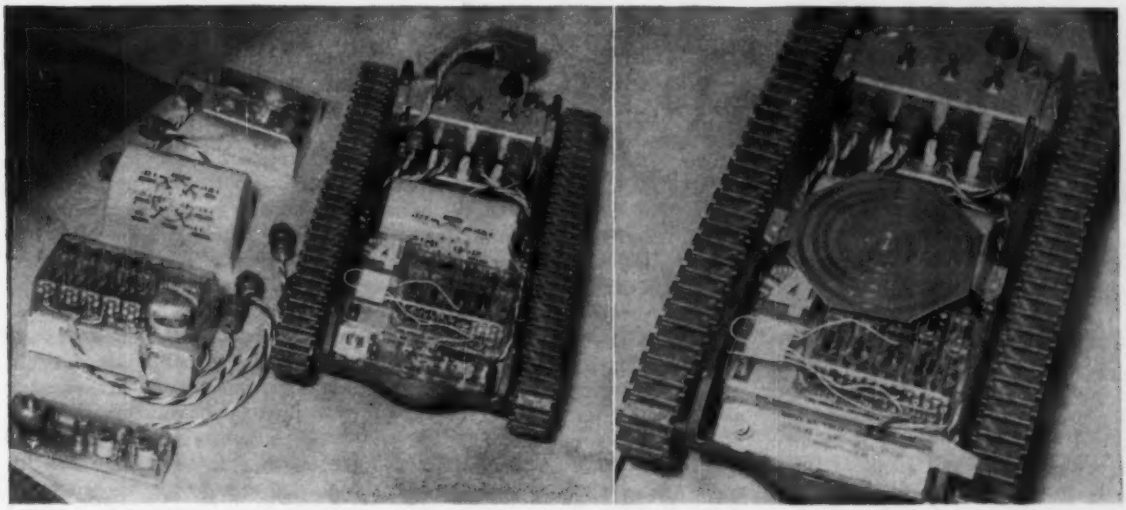


FIG. 5—Tank electronics are packaged and mounted as shown in the left photo. Power is supplied to the turret through the etched slip ring shown in the photo at the right. Red indicator lamp on rear apron comes on when tank is killed

tanks. Each tank gun is fitted with a lamp and lens combination that can project a fairly narrow beam of light approximately 25 ft. A direct hit from the light gun of one tank on the photocell of another automatically triggers a disabling relay that cuts off power to the tank drive motors. This permits the tanks to kill or be killed. When a tank is disabled by gunfire, a red indicator lamp located on the rear apron of the tank comes on. A manual override switch can be operated to restore the tank to action.

The turret receives its power through an etched circuit slip ring as shown in Fig. 5. The internal components are packaged in plastic and are interconnected by cables and plugs.

Fifteen radio-controlled models are used on a 76 by 29 foot terrain board containing various types of natural and man-made features scaled in ratio to the model tanks.

When the battlefield is in operation, tank crew members sitting on a steel platform that can be moved over the terrain board control the model tanks to carry out tactical movements. Using the conventional f-m radio equipment from the full-size tanks, the tank crew can give and receive orders. During exercises, a five-tank platoon can be put through a series of tactical maneuvers against a five-tank platoon of enemy tanks. Artillery fire is simulated with explosive pellets fired from an air gun, landmines are simulated by concealed firecrackers and atomic explosions (such as shown on the front cover) are simulated by flash gun powder.

Although evaluation of the training effectiveness of the miniature battlefield is still underway, preliminary results indicate that soldiers trained indoors with the scale model radio-controlled tanks fight real tanks under actual field conditions better than soldiers who were not so trained.

The development of the radio-controlled models constitutes a break-through in realistic combat training and results in marked improvement in the conduct of field operations and the savings of large numbers of tax dollars.

The author wishes to acknowledge the services of F. Hoover, F and M Electronics, Albuquerque, New Mexico and H. T. Bonner, Bonner Specialties, Culver City, California for their help in the design of the scale-model tank system.

Systems Applications of SOLID-STATE MASERS

Survey of progress in solid-state masers describes applications, possible new materials and future trends. Also, principles of maser operation and circuit design are outlined

By JAMES W. MEYER, Associate Head, Radar Div., Lincoln Lab., MIT, Lexington, Mass.

SOLID-STATE MASER AMPLIFIERS have made significant contributions to space radar, space communications and the improvement of existing electronic systems in the four years since they were first proposed.

Development of low-noise microwave amplifiers have also had many side benefits. Most important were stimulation of basic research into the properties of paramagnetic materials and showing the necessity for further development of low-noise components and efficient microwave circuits. Attempts to improve cryogenic apparatus and experimental techniques have been encouraged by potential maser users. Also, the existence of the solid-state maser with its extremely low noise properties has stimulated significant advances in the development of competing methods of low-noise microwave amplification, such as parametric amplifiers.

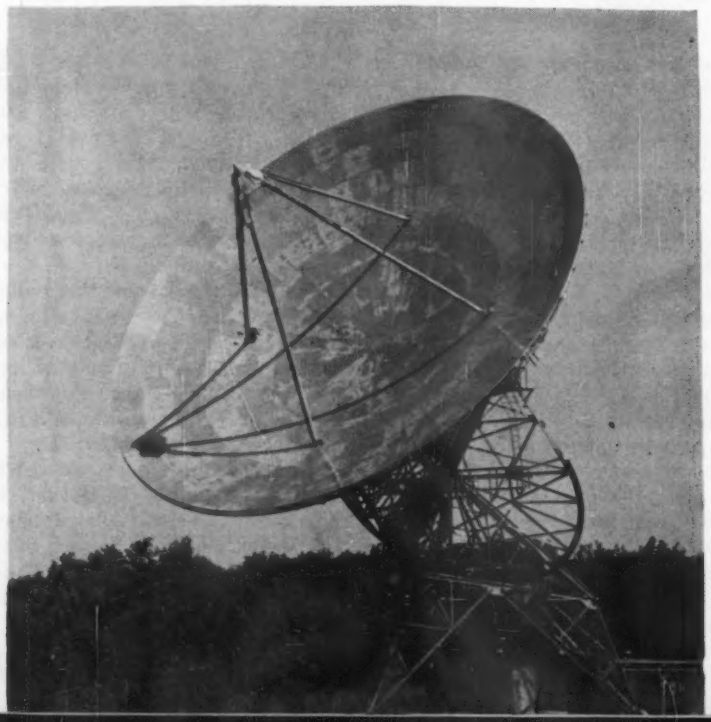
The maser's potential has only begun to be realized. Millimeter-wave masers of the c-w and pulsed field types are being developed. Infrared and optical masers have been proposed; in a recent breakthrough, a version of the latter has been operated successfully.[1] Researchers are working on new materials, circuit design, auxiliary apparatus and microwave power supplies.

Applications potential is exciting. The maser is intimately concerned with our exploration of space. Antennas probing space are frequently pointed at the relatively cool sky thereby having the low-noise temperature required to get the most from a low-noise maser receiver.

Detection of the planet Venus is an example of a deep space radar probe.[2] Further improvement of radar power and antenna aperture and the use of refined solid-state masers should put the entire solar system within radar range.

Use of a maser will permit reducing the weight of spaceborne transmitters without degradation of the quality of the information communicable, thus providing extra space and weight for scientific apparatus or reducing required booster thrust.

The potential of sextants using radio sources is becoming more and more attractive because of their all-



An X-band maser package is located at the prime focus of University of Michigan's 85-foot radio telescope at Peach Mountain Observatory

SYSTEMS APPLICATIONS OF SOLID-STATE MASER AMPLIFIERS UP TO MARCH, 1960

Organization and Application	Improvement Factor with Maser	Frequency (Mc)	Effective System Noise Temp (deg K)	Aperture Dia (ft)	Remarks
MIT Lincoln Lab; Venus contact from Westford, Mass. (Millstone Hill radar) Feb. 1958. Transmitter power: 60 Kw average, 1 Mw peak	3.5 times	440	200	84' (2 beamwidth, 37-db gain, dual polarization)	First application of solid-state maser. Effective noise temperature was reduced from 700 K to 200 K using maser
Harvard College Obs; hydrogen line radio astronomy, 1959. Cavity maser mounted at focus[6]	5 times	1,420	85	60	This application relatively long in coming; was initially thought to be most promising possibility
Bell Telephone Lab; 8-Mc bandwidth, 1959. Applied traveling-wave maser to a low-noise horn-type antenna[7]. Used with Project Echo maser	Not used without masers	5,650	17.2 minimum (including sky noise)	7 (equivalent)	Extremely low effective temperature permitted accurate evaluation of sky noise temperature
Univ. of Michigan radio telescope; 8-Mc bandwidth Feb. 1960. Cavity maser mounted at focus[8]	8 times	8,500	100	85	Complete radiometer developed to reduce effect of system gain fluctuations (see text)
Columbia Univ.—NRL; detection of cosmic noise, April 1958. Minimum fluctuation level was 0.04 K[9]	12 times	8,700–10,000	85	50	First application of a maser to passive detection of cosmic noise
Hughes Aircraft Co.; ground test of airborne tracking radar, 1959[10]		9,300	170		Most of system noise was contributed by duplexer

weather capability. By increasing sextant sensitivity, masers increase their versatility because fixes can be taken on a large number of radio sources. An increase in receiver sensitivity frequently allows a reduction in antenna size, an important fact for portable operation.

In radio astronomy, masers are expected to contribute significantly to extra-galactic investigations, which should reveal much about the nature of our universe.

The realization of world-wide reliable communications by means of satellites is near at hand. Increased sensitivity of receivers will increase the information-handling capability of communications systems employing reflections from passive orbiting satellites. (ELECTRONICS, p 43, Sept. 30)

The list of applications where the maser has already been put to work is impressive. As a device, the solid-state maser is relatively young. Following the original proposal by Bloembergen in 1956,[3] the concept was tested in the laboratory by Scovil and co-workers in 1957[4] and shortly thereafter was arranged to function as an amplifier on which noise measurements were made at Lincoln Laboratory.[5]

By February 1958, the maser had already been put to work at Lincoln Laboratory.[2] Since then there have been at least five other applications of masers to electronic problems. Table I includes those documented in the normally available technical literature up to March 1960.

Figure 1A shows the switching techniques used to reduce the effect of system gain fluctuations in the complete radiometer developed by the University of Michigan. Gain fluctuations are more troublesome as the difference between the radiation received through the antenna and that received through the comparison circuit becomes greater. The variable attenuator in the comparison horn circuit permits equalization of the two sources. The maser is packaged as shown in Fig. 2B. (ELECTRONICS, p 43, Sept. 30)

Masers have been operated with pulsed output at frequencies up to 70 Gc[11] and as c-w amplifiers up to 40 Gc[12]. Between these millimeter-wave frequencies and the lowest reported maser operating frequency (about 300 Mc)[13] masers have been operated at numerous spot frequencies in the L, S, C, and X bands.

Atmospheric absorption has plagued the designer of millimeter-wave systems in the past, but with the advent of space investigations these wavelengths will assume a new and dramatic role in the exploration of the earth's cosmic environment.

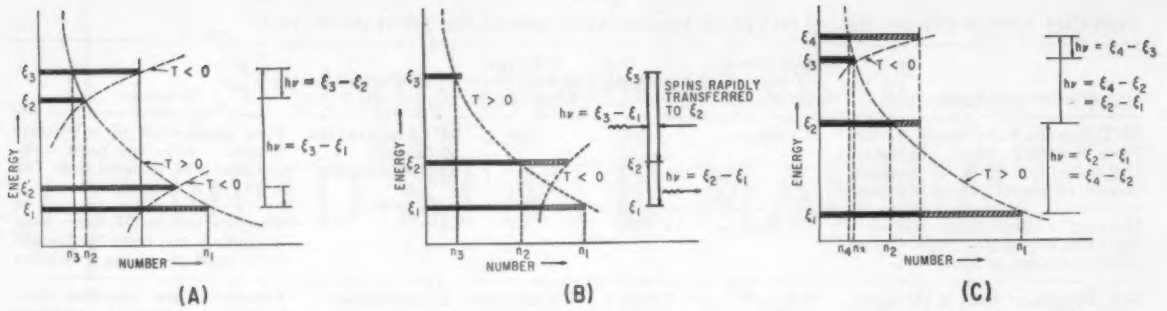
At the lower frequencies there are a number of devices that compete adequately with masers as low-noise amplifiers. Expressions for the gain of masers show that as the frequency goes up they become easier to build. This is not the case with a number of competing devices. Exploitation of higher frequencies where the advantage of the maser is so clearly apparent will require special attention to the discovery of new materials and the development of adequate sources of high-frequency pump power.

Combination of new millimeter-wave maser and novel superconducting electromagnet, which provides the necessary magnetic field, has drastically reduced the size of the maser package (see Fig. 2).

The future of masers depends on hard work; the glamour of novelty is beginning to wear off. The problem is to convert laboratory prototypes that require meticulous adjustment and careful handling into the rugged devices required in the field.

Since competitive methods exist for doing low-noise amplification jobs, it will be necessary to become familiar with masers from many points of view. It is only on the basis of a broad understanding of the subject that intelligent and economical decisions can be made regarding specific applications. Masers offer no panacea, but they have demonstrated their ability to make significant improvements in existing systems and their further exploitation depends on ingenuity and application to the work ahead.

As discussed in the editorial box,



PRINCIPLES OF MASER OPERATION

The basic problem in a solid-state maser is to get a net emission of microwave energy from a solid. Incident radiation that is resonant with the separation of energy levels in this solid stimulates not only emission of energy, but absorption of energy.

In the usual equilibrium situation, the absorption always exceeds the emission because in equilibrium the population of a lower energy level always exceeds that of an upper energy level. To get a net emission of microwave energy, the higher energy level must be populated in excss of a lower level. There are a number of ways of bringing about this situation. In a gaseous maser, for example, particles in the lower energy level are sorted out and removed by selective electrostatic focusing. In the solid-state maser, a method of selectively depleting the population of a lower lying energy level is used.

For a paramagnetic solid, the energy levels of primary interest are those corresponding to the several possible orientations of the magnetic moment of a spinning electron in a magnetic field. Spacing of these levels and therefore the frequency of the radiation resonant with this spacing, can be changed by varying the magnitude and orientation of an applied magnetic field.

Orientation of the assembly of electron spins relative to the applied magnetic field is described in terms of the number of spins (particles) occupying the several energy levels. An electron spin that is nearly aligned with the applied magnetic field occupies the lowest energy level; higher levels represent poorer alignment.

Perfect alignment (all spins in the lowest level) is prevented by the effect of thermal vibrations in the solid. These thermal vibrations have an amplitude and frequency distribution determined by the absolute temperature of the solid, T.

At high temperatures, the large amplitudes of these vibrations prevent much spin alignment even in the presence of fairly large magnetic fields. At equilibrium, the distribution of spins over the energy levels is given by a Boltzmann distribution and is illustrated graphically in (A). Boltzmann's equation for the number of particles n_i, having the energy ϵ_i, at an equilibrium temperature T is

$$n_i = N_o (e - \epsilon_i/k\,T) \Big/ \sum_n (e - \epsilon n/k\,T)$$

The constant k (Boltzmann's constant) relates the absolute temperature to energy.

For positive temperatures, the population of higher energy levels will always be less than that of lower levels. If microwave energy is applied to the solid resonant with the separation between two of the energy levels, say ϵ_1 and ϵ_2, there will be an absorption of energy. Absorption is accomplished by the elevation of particles from the lower to the upper state.

There are three ways by which particles return to the lower levels; by spontaneous emission, by transitions stimulated by the incident energy, and by the transfer of energy between the particles and the vibrations of the solid lattice. If the incident microwave energy has sufficient power, the rate at which the particles are taken from the lower level to the upper level will exceed the rate at which they are returned to a lower level.

By further increase of incident power, it is possible to equalize the population of the two energy levels. This condition is known as saturation. When the populations are equalized, the incident radiation stimulates absorption and emission by an equal amount and no further change can be made by increasing power.

With the saturation accomplished, levels lying intermediate to those being saturated exhibit a relative population inversion. If, for example, the intermediate level lay close to the upper level, then the upper level is populated in excess of the intermediate level. However, if the intermediate level is located close to the lower level, the intermediate level is populated in excess of the lower level.

Thus, by the selective depletion of a low-lying energy

it is possible to get a net emission of microwave energy from a solid. Power supplied to the solid is also in the form of microwave energy. The fact that there is emitted power permits a negative magnetic Q to be defined in a manner analogous to the definition of a positive Q in ordinary circuits as follows:

$$Q_m = \frac{\omega \times \textit{peak energy stored}}{\textit{power emitted}}$$

where ω is angular velocity and Q_m is magnetic Q.

The basic problem of the circuit designer is the utilization of this negative Q in a microwave circuit. It can be shown that the voltage gain-bandwidth product for the cavity is approximately given by

$$G_v B \approx 2f/Q_m$$

where G_v is voltage gain, B is bandwidth, f is signal frequency and Q_m is magnetic Q.

Where the interaction of the negative Q is with a traveling-wave circuit, the gain in db is given by

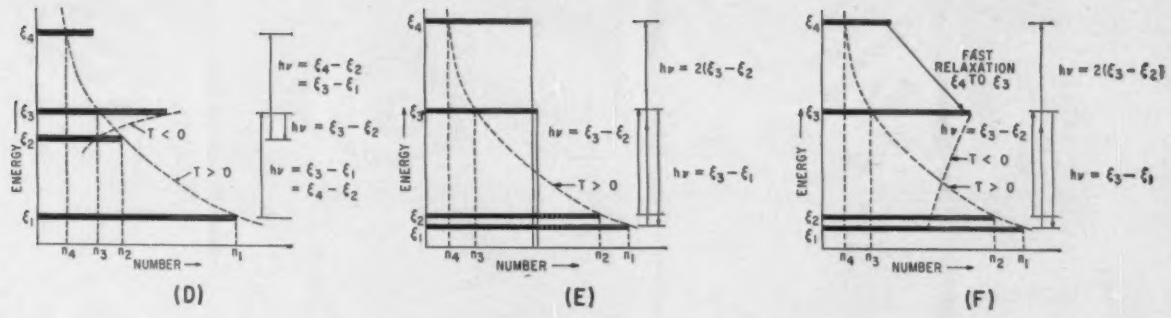
$$G_{db} = 27.3\,(L/v_g)\,(f/Q_m)$$

where G_{db} is gain in db, L is the length of the circuit, v_g is the group velocity, f the operating frequency and Q_m the absolute value of the negative Q. Effectively, the ratio L/v_g is the time that the wave packet spends in the interacting circuit.

Bandwidth of the traveling wave maser is given by

$$B = [\ln 2/(\ln G/2)]^{1/2} \Delta f_m$$

where G is the numerical power gain and Δf_m is the width of the resonance absorption line in the maser material. This line width is just the bandwidth of the traveling-wave maser if the gain of the maser is four. As can be seen from these equations, the problem of relating emitted power to the constants of the circuitry is getting the maxi-



level an inversion of the population is accomplished. An inverted population distribution can be thought of in terms of a negative temperature because a negative temperature inserted in Boltzmann's equation gives the increasing exponential characteristic bounding the inverted energy level population as shown in (A) and (B).

With the population inversion accomplished for a pair of levels, weak incident radiation resonant with the inverted level's separation will stimulate a net excess of coherent radiation, hence produce amplification.

In (A) there is a location for the intermediate energy level that would not result in a population inversion. This situation occurs when equilibrium population at the location as given by its position on the diagram is coincident with the population of the two extreme levels when saturated.

What can be done should this situation arise is illustrated in (B). If by some means, natural or artificial, the spins that have been raised to the upper level by the saturating power are rapidly transferred to the intermediate level, a population inversion can be created between the intermediate and lower levels. This technique was used in the first laboratory demonstration of the maser principle. Rapid transfer of spins was accomplished by the inclusion of an impurity material in the maser crystal.

In those solids having more than three energy levels, other things can be done to create a population inversion. An example of what has been called push-push pumping is shown in (C). The separations of energy levels 1, 2 and 2, 4 are made resonant with the incident pumping radiation. Populations of these levels are equalized in the manner shown resulting in an excess population of 4 over 3.

As has been perhaps intuitively apparent, population inversion is greater and hence emission of microwave energy is greater as the spacing between the levels being pumped becomes larger compared to the energy spacing of the signals levels. Push-push pumping provides a means of getting this improved ratio without the necessity of having to use high-frequency pumping energy.

A similar effect can be produced in a three-level maser crystal at half the frequency required in push-push pumping. As shown in (D), this is done using push-pull pumping in which spins in level 1 are pushed into level 3 and spins in level 2 are pulled into level 4. The result of this arrangement is an enhanced population difference between levels 2 and 3.

In four-level materials, it has been shown possible to produce maser action at frequencies higher than the incident pumping frequency.[14] This method of operation is illustrated in (E). Incident energy is resonant at the frequency corresponding to the separation between energy levels 3 and 2, but there is also a harmonic relationship between this separation and the separation between energy levels 4 and 1.

As a result of complicated coupling within the solid itself, it has been shown possible to saturate effectively the transition between levels 1 and 4 and create a population inversion between levels 1 and 3. Separation between levels 1 and 3 exceeds that between 3 and 2; hence the emitted energy is of higher frequency than the pump energy.

Emitted power can be increased if a fast relaxation occurs between levels 4 and 3 as shown in (F).

If the relaxation, or transfer of spins from level 4 to level 3, occurs rapidly relative to such transfer between other pairs of levels (F), level 3 will have a larger population than it does in the case of equal relaxation times (E) hence its excess population over level 1 is greater. As a result, the emitter power resulting from transitions from level 3 to level 1 is greater. Fast relaxations for certain pairs of levels can occur naturally or may be produced artificially by suitable doping. Recent measurements have indicated that the natural difference occurs in at least one material—ruby.[15]

mum power possible from the paramagnetic material and at the same time reducing the circuit losses to a minimum.

Low-noise properties of maser amplifiers have been shown to live up to all expectations[5, 16]. Inherent noise in the maser is the result of spontaneous emission; the lower limit on the effective noise temperature of a maser is set as $T \geqq hf/k$ where $h/k = 5 \times 10^{-11}$ sec/deg K. Evaluation of h/k (the ratio of Planck's to Boltzmann's constant) shows that this limiting temperature is 5 K for a frequency of 100 Gc, and is 50 K for a frequency of 1,000 Gc. Therefore, frequencies in the microwave and millimeter-wave bands are low enough to make the lower limit of noise temperature inconsequential.

Development of adequate materials is an important problem area. The properties of paramagnetic materials strongly affect operating characteristics of the maser such as gain, temperature at which they must be operated, bandwidth and frequency of operation.

The Cr^{3+} ion has proved to be a most versatile paramagnetic in a number of host diamagnetic materials. In the potassium cobalticyanide host lattice, for example, this ion has been used in the uhf, L-band and S-band masers described earlier.

When hosted by sapphire (Al_2O_3) the Cr^{3+} ion forms ruby which has been widely employed as a maser material, in particular for those employing push-pull pumping.[17] Ruby has also permitted the operation of a maser in the millimeter wavelength region.[18] Popularity of ruby is undoubtedly based not only on its fine electrical characteristics,

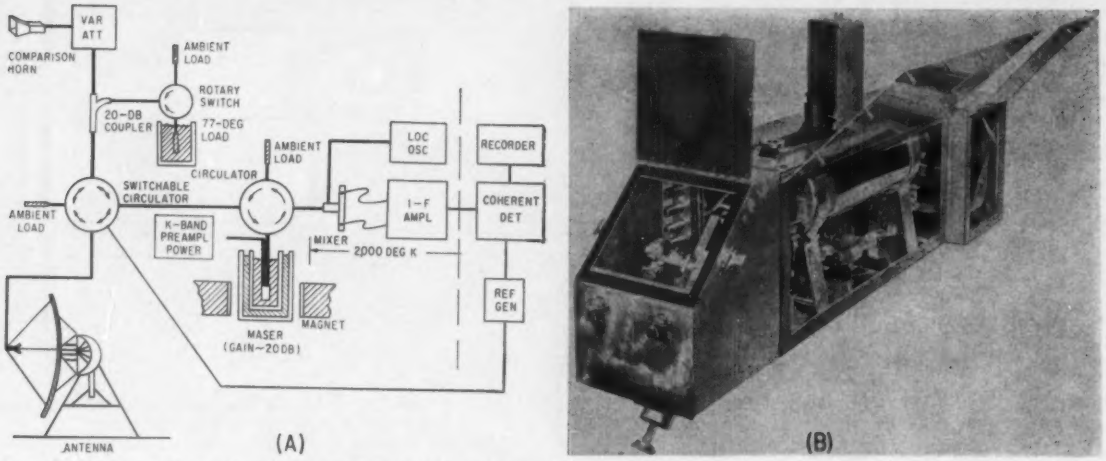


FIG. 1—Radiometer developed by University of Michigan (A) reduces effect of system gain fluctuations. Packaged unit (B) is four feet long by one foot square and weighs about 250 pounds

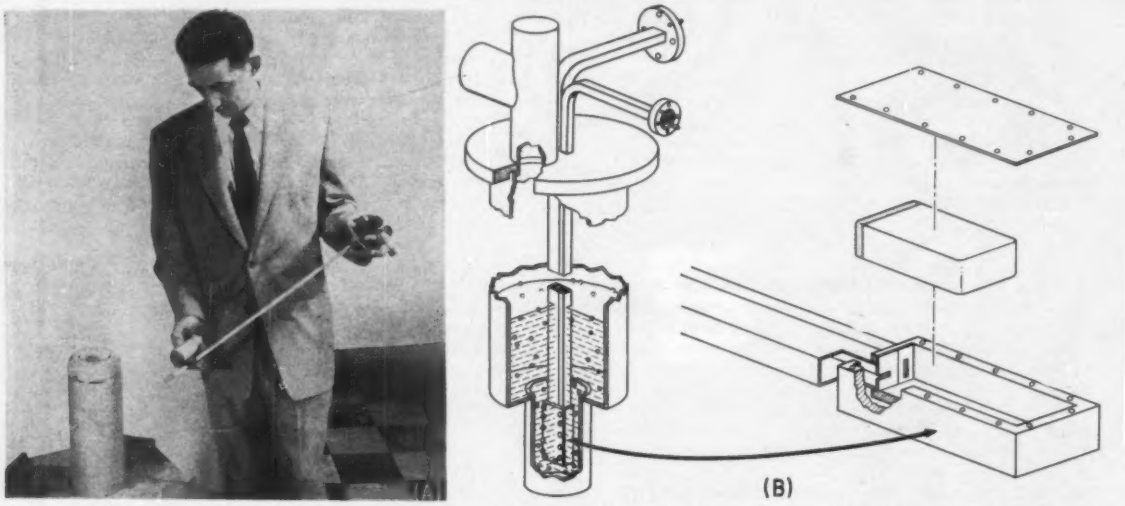


FIG. 2—Millimeter-wave maser (A) developed at Lincoln Lab uses a small superconducting electromagnet (shown in right hand of author). Details of maser cavity and cross-section of low-temperature dewar with maser in place are shown in (B). Active material is dark area at end of dielectric slab, which almost completely fills cavity

but on its physical ruggedness and its commercial availability.

Ruby has provided the first breakthrough in the infrared optical masers. Experiments on the optical and microwave-optical properties of this interesting material preceded the maser development.[19] The large dielectric constant of titania (TiO_2) made it an attractive host material. Titania doped with Cr^{3+} has been used for maser operation at 8.2, 10.6 and 22.3 Gc.[20]

A companion of chromium in the iron group, the Fe^{3+} ion, has been found useful both in sapphire where it operated at X-band with essentially no applied magnetic field[21] and in titania where it produced an eight-millimeter c-w maser.[18] Recently, Bleaney[22] proposed a new class of maser materials of which the Co^{2+} cerium ion in a host crystal with cubic symmetry is an example.

Designers would like a catalog of maser materials and their properties so the maser could be more adequately tailored to the problem at hand. There are literally thousands of compounds that are potential maser materials, but the field narrows when they are subjected to tests and standards such as low dielectric loss, proper magnetic behavior, chemical stability, mechanical strength and availability. Gems, precious and semiprecious, have been an interesting area for materials explorations[23], but a vast amount of experimental work must still be done before a catalog of materials becomes a reality.

Masers cannot perform alone—a retinue of associated equipments is required. In the final analysis, performance of a maser system is often limited by performance of the auxiliary apparatus. Therefore, to exploit fully the low-noise feature of the maser, auxiliary apparatus must be carefully engineered.

Antennas for masers should have small back lobes to avoid interception of the relatively hot ground when pointed well above the horizon. Small side lobes are desirable to avoid intercepting other hot spots and raising the effective temperature of the antenna. Small back

lobes have been achieved at Bell Telephone Laboratories with the horn antenna mentioned in Table I.

If a large area on the ground around the antenna is covered by a reflecting material, the noise entering the antenna through the side and back lobes is the relatively cool sky noise. Transmission lines employed with masers must be designed either to have low loss or some provision must be made for cooling them.

Achievement of directional and stable gain in masers usually requires the use of isolators or circulators. Ferrite isolators operating at low temperatures have been made an integral part of traveling-wave masers. Low-loss circulators have been made and circulators operating at liquid helium temperatures have been used.

Because of their inherent extreme sensitivity, masers are subject to saturation of gain by excessive signal power. This places stringent requirements on switches used to protect masers when used with radars.

Two approaches have been used for solving the switch or duplexer problems for masers; a polarization twist technique in ferrites[10] and the avalanche breakdown in a semiconductor. Use of these devices in the systems for additional protection over that provided by the normal radar duplexer has adequately protected the maser.

Provision of a magnetic field is essential for operation of most masers. The magnetic field required varies greatly with the application and the material employed as the paramagnetic substance. While early masers were operated with large, unwieldy, research-type electromagnets, more recent designs have employed small permanent magnets equipped with auxiliary trimming coils or, in those cases where not much field was required, small air core solenoids.

It has been found possible to establish adequate magnetic fields for many maser applications using superconducting solenoids and iron-core magnets which require no further power source after the desired field has been established.[24] These magnets operate at liquid helium temperatures in the same bath as the maser and maintain the established fields by the circulating current in superconducting coils. Niobium, with its high transition temperature, has been found very satisfactory for this purpose.

Another important auxiliary device is the pump power source or the microwave power supply. Normally high-frequency sources are needed with reasonable amounts of power output to adequately saturate resonances in paramagnetic materials. As the frequency range of masers is pushed up into the millimeter-wave region, pump power sources will be needed at these or at higher frequencies.

Thus far, more or less conventional and familiar auxiliary equipment has been described. The maser also requires a low-temperature environment which calls for low-temperature apparatus and cryogenic equipment. These low temperatures can be achieved by immersing the maser in a liquefied gas or in cold reservoir of a cyclic refrigerator.

Small cyclic refrigerators for use with field devices and designed to achieve temperatures in the liquid helium region are now under development. Availability of such a device will go far to alleviate the logistic problem associated with providing liquefied gases at remote field sites.

To achieve satisfactory gain, bandwidth and stability in a maser amplifier, a maser designer must consider the following factors.

The magnetic Q must be minimized. This result can be obtained by combining materials, operating temperature and microwave circuits so that a maximum amount of stimulated emission is achieved.

The bandwidth of the maser must be considered because it is related to the linewidth of the material; the latter is an important parameter to the maser.

To insure adequate gain stability and unidirectional gain, the unidirectional properties of the right- or left-handed circular polarization component existing in many slow-wave structures or in microwave transmission lines must be utilized to get large forward-to-backward gain ratios. It may be desirable or necessary in some cases to equip the maser with a compatible isolator that will attenuate the signal in the reverse direction. Isolators should operate at low temperatures.

Since 1958, traveling-wave masers have become practical.[25] The ruby has emerged as a versatile, effective material and iron-doped titanium dioxide has opened the millimeter-wave area. Ruby materials have enabled masers to operate at liquid nitrogen temperatures[26] and there is every indication that it will be possible to operate masers in the liquid hydrogen temperature region (about 20 K) where refrigeration problems are much less severe. It is not likely giant strides in maser development will continue, but dramatic results from system performance can be expected in the near future.

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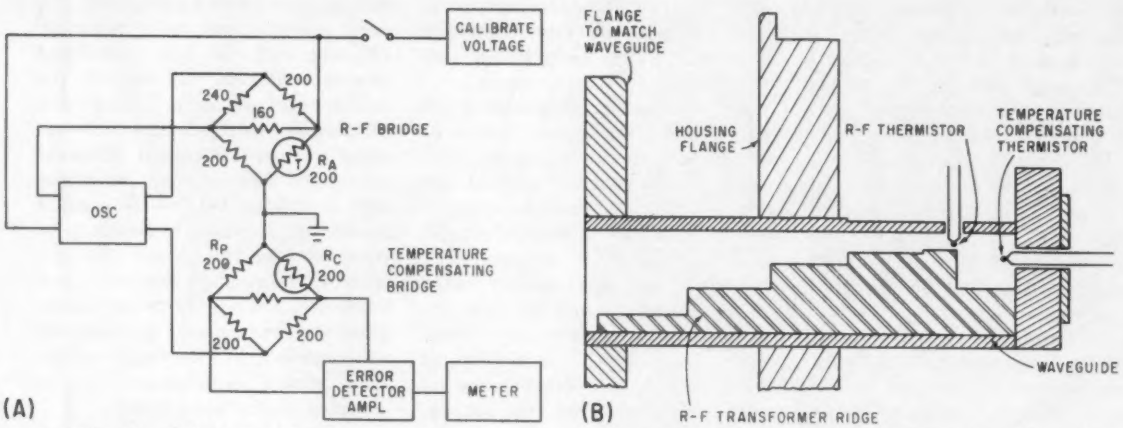

Dual bridge circuit (A) uses identical thermistors for power measurement and temperature compensation. Thermistors in (B) are in the same ambient temperature but only one thermistor is exposed to the r-f field

Temperature Compensated R-F Power Meter

Dual bridge circuit controls oscillator output to stabilize power dissipation in thermistor measurements. Temperature effects are reduced by a factor of 100

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BOLOMETRIC measurement of low-level r-f power is so complicated by changes in ambient temperature that measurements are difficult and often inaccurate. Typically, for uncompensated measurements, a thermistor or barretter absorbs energy from the r-f field, and the heat generated changes the resistance of the measuring element in proportion to the incident r-f power. In thermistors generally used in r-f power measurements, a change of only one microwatt of absorbed power causes a change of 0.003 degree C in the operating temperature of the thermistor. Similarly, a change in ambient temperature of 0.003 degree C results in a measurement drift of 1 μwatt. Thus, temperature compensation is required for low level power measurements.

The dual bridge circuit of Fig. 1A reduces drift through ambient temperature changes by a factor of 100, so that 0.3 degree C instead of 0.003 produces 1 μwatt drift. The r-f power measuring bridge is used in a forced-power balance system, with power in R_A held constant; the other bridge provides temperature compensation and develops the output signal.

The power meter substitutes audio power for radio-frequency power. Excitation for the bridges is by an audio oscillator whose power output is controlled by the unbalance of the r-f bridge. Oscillator gain is low with a relatively large unbalance, making the power output of the oscillator dependent on the resistive balance of its controlling bridge and relatively independent of residual reactances in the bridge arms. The gain of the oscillator is preset to maintain the r-f thermistor at 200 ohms. For the values shown in Fig. 1A, a gain of approximately 100 is satisfactory.

The special thermistor mount (Fig. 1B) used with the power meter contains two thermistor elements. One element is in the r-f field and the other is out of the field but in close proximity. The mount also contains a precision resistor that determines the operating conditions of the thermistor elements and allows interchangeability of mounts. The thermistor in the r-f field is an arm of the r-f bridge, and the temperature compensating thermistor and precision resistor become arms of the temperature compensating bridge. This bridge is balanced with no r-f power, which requires maximum oscillator output.

With r-f power, resistance of the r-f thermistor decreases. This change in resistance decreases feedback to the oscillator, thereby lowering its output. The new steady-state condition is such that the thermistor element is maintained at 200 ohms by the decrease in audio power. Audio power change is proportioned to r-f power applied to the thermistor and net power dis-

Temperature compensated power measuring unit connects to waveguide by flange mounting plate

sipated in the r-f thermistor is unchanged.

Decrease in oscillator output affects the temperature compensating bridge and causes the impedance of its thermistor element to increase, thereby unbalancing the bridge and providing an output signal. For small increments in power, the output voltage of the temperature compensating bridge is linear and directly proportional to r-f power. Thus meter indication is linear and proportional to the power being measured.

A change in ambient temperature causes the thermistors in both bridges to change resistance simultaneously. The change in the r-f thermistor increases or decreases oscillator output such that the steady-state value of 200 ohms is maintained. This change in audio power is also applied to the temperature compensating bridge. If both thermistors are identical, the change in audio power is just enough to return the temperature compensating thermistor to its original value. Since the power sensitivity of thermistors is almost constant over a reasonable temperature range, power readings are temperature compensated throughout the range of interest.

Instrument calibration requires bridge balancing and gain adjustments for zero and full scale r-f power. For the zero-power calibration, oscillator gain is adjusted to maintain thermistor R_A (Fig. 1A) at 200 ohms and R_F is simultaneously adjusted to give an output null to the error detector. Full-scale calibration is obtained by feeding d-c power to the r-f thermistor and adjusting the error detector amplifier accordingly.

The power meter may be used for measurements from 10 Mc to 40 Gc. A coaxial thermistor mount covers the 10-Mc to 10-Gc range and wave guide mounts for L- to K-bands extend the range to 40 Gc.

Maximum accumulative error at full scale on all power ranges, excluding the calibration factor of the thermistor mount, is ± 2.5 percent. At less than full scale on the 0.01, 0.03, 0.1 and 0.3 milliwatt ranges, the maximum error increases by an additional 0.7 percent of full scale. The increase is caused by errors in meter tracking and in the detector amplifier, resulting in a maximum cumulative error over the scale of these ranges of 3.2 percent. The calibration factor for a typical X-band mount was determined by the Bureau of Standards to be 0.973, 0.982 and 0.980 at 9, 9.8 and 11.2-Gc respectively.

The error on the 1- and 3-milliwatt ranges is slightly higher, approaching a maximum total error over the 3-milliwatt range of ± 5 percent of full scale. The added error on these higher range scales is caused by deviation of the thermistor from a true square-law characteristic, variation of the excitation voltage across the temperature compensating bridge and bridge unbalance.

Precision Servo Regulator Controls

Double-loop servo system holds the field of large electromagnet constant

By A. M. PATLACH,
IBM Watson Laboratory, New York, N. Y.

CERTAIN EXPERIMENTS in particle physics require close control of the field of large electromagnets with excitations on the order of 50-Kw. A high-gain, wide-range current regulator is described which has a field-measuring device connected as part of the control loop.

The proton resonance technique, by which the field is both measured and controlled, is an extremely sensitive and narrow-band phenomenon. In hunting for resonance it must be possible to vary the current by very small increments. Once set, the magnet current must remain stable to at least a few parts per million. After the desired field has been established and control is given to the field-sensing device, the field control is maintained automatically.

The system described performs these functions by use of a double-loop servo which regulates the current initially. The primary-loop or rough regulator establishes a small region over which the fine regulator operates. The rough regulator is slow responding, nondissipative and has low gain. The fine regulator is a faster, high-gain d-c transistor amplifier that performs its function by dissipating some of the available power. For this reason the rough regulator is required, otherwise efficiency would be low and the range narrow.

Output of the field sensing device is arranged so as to modify the control voltage to the fine regulator and thus maintain the field in the face of inevitable magnet parameter changes and reference voltage drifts. It is possible to regulate the current with the transistor regulator alone to a stability of better than 1 part per million. When the output of the field-sensing device is coupled to the system, it is possible to control the field, at one point, to one part in 15 million. The current regulator is a more complete version of a precision regulator already described.[1, 2, 3]

The block diagram in Fig. 1 shows the fine and coarse regulating loops, and the field-locking servo loop. The transistor fine regulator is placed in series with the output of a motor generator. The transistor section is of the series-pass type and can dissipate up to 1.1 kw. Therefore, unless the system is to operate over an extremely narrow range, auxiliary coarse current regulation must be provided.

Current is sensed as the voltage drop across a four-terminal 0.5 milliohm shunt. Using such a small resistance eliminates dissipation problems and resistance changes due to heating.

To establish the desired current, a stable reference voltage is added to the potential developed across the shunt. The difference between them is amplified by a chopper amplifier and a transistor d-c amplifier, and fed to the pass transistors. Net voltage to the chopper amplifier is the amount required to establish a current flow of between 0 and 15 μa at the chopper output. Fifteen microamperes at the d-c amplifier input will drive the pass transistors to minimum voltage drop.

The coarse regulator controls the generator output to maintain a given voltage drop across the pass transistors. This voltage is chosen to limit the dissipation to a maximum of 1.1 kw. The minimum satisfactory drop is about 1.5 v. Since the regulator holds constant the voltage across the load in the face of generator ripple, the operating point must be chosen so as not to allow the transistors to be driven below 1.5 v.

As the operating voltage is raised, dissipation must increase. Therefore, the lower the ripple the less power will have to be dissipated. To smooth the input, a choke is placed in series with the generator and is shunted by a filter capacitor bank built into the regulator.

The coarse regulator must have two leads coming directly from the pass transistor panel. If the generator negative terminal is used as one lead, the voltage drop in the cable impairs both regulation and stability of the feedback loop.

To minimize instability caused by time lags in the rough regulating loop (at certain currents there is a 30-sec lag between change in generator output and change in excitation for our generator) rough correction is not continuous. Rather, a dead range of about 1 v is provided over which the fine regulator fixes the current. The rough regulator response must be slow compared to that of the fine regulator; otherwise oscillations will occur.

Large magnets exhibit a change in current/field characteristics after they have been energized. This is in part due to geometry changes as the magnet heats and to permeability changes with temperature. These changes are sufficiently large to warrant the addition of a field sensing device to correct the field current as necessary. An additional benefit is that much less demand is placed on the reference voltage stability. The field-lock output is arranged to decrease the reference voltage when the field is high and to increase the reference voltage when the field is low.

Ultimate current handling capacity is limited only by the number of paralleled power transistors used. Earlier versions were designed to control currents up to six amperes; a later model can control 350 amperes.

Although the current control loop in the fine regulator has very high d-c gain, it has poor response to any a-c signal whose period is less than 12 seconds. Such a condition might produce instability in the circuit

High-Power Magnetic Field

to one part in fifteen million

if the load introduces any lag in the current flow. To overcome this difficulty and to enable the regulator to remove power supply ripple and respond quickly to generator fluctuations, two parallel a-c coupled voltage feedback paths are used to bypass the current control loop and provide high a-c gain.

Stability is ensured even though magnet-chopper-filter phase shift exceeds 180 deg at some frequency. Voltage feedback at this frequency is greater than current feedback and is degenerative. Because the gain and phase shift at higher frequencies (5 Kc and up) varies due to transistor characteristics, the preamplifier is shunted by large electrolytic capacitors to suppress any high frequency signal.

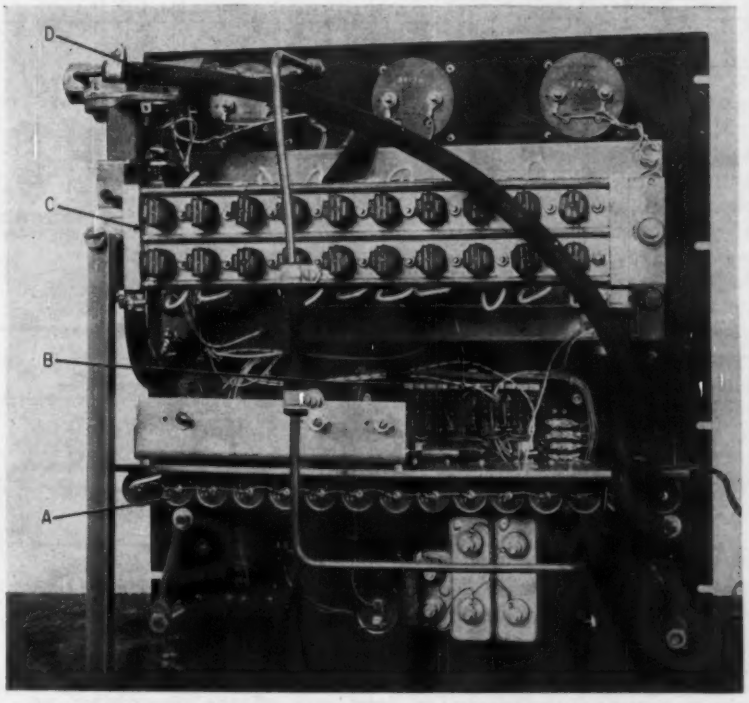
The transistor section is built on two chassis; one is the power handling section, the other the preamplifier. The pass transistors and drivers are mounted on a water-cooled 6 × 16 × ¼ in. copper plate. Cooling water circulates through three ½ in.-copper tubes sweat-soldered to the plate. Current equalizing resistors in series with each pass-emitter are mounted on a separate ¼ in.-thick water-cooled plate. Both these plates are used as electrical conductors to minimize any voltage drop that might make the transistor load sharing unequal.

Another precaution against unequal loading of the pass transistors is a 12-gauge base bus. The 0.2-ohm resistors equalize collector currents to within about 3 percent at 200 amperes. The driver transistors Q_2 and Q_3 are paralleled and current equalized. One transistor could supply the 12 ampere maximum driving current, but high gain is preserved by paralleling two transistors since the 2N441 beta begins to fall off in this region.

Fine regulation is accomplished by feeding the difference between the reference voltage and the voltage drop across the ½-milliohm shunt into a null indicator, adapted by bringing the meter output outside the case and removing the ground lead from the input filter condensers. The meter provides a handy check on the system's operation.

The d-c signal from this instrument has several volts of 60 cps superimposed on it, which, if fed to the transistor regulator, appears at the load. A twin-T filter between the null detector and regulator in conjunction with the long input time constant brings the 60 cps at the load below 1 mv.

When the reference voltage is greater than the shunt drop, the output of the null amplifier swings negative. This current flows through the filters mentioned previously (see Fig. 2) then through a 1,000-ohm resistor to the base of Q_6. Collector current of Q_4 increases, decreasing the base current of Q_5. This action decreases the collector current of Q_5 causing point *A*



Behind capacitor bank of current regulator (A) is chassis with transistor preamplifier (B). On upper panel (C) are current equalizing resistors. Water interlock is shown at (D)

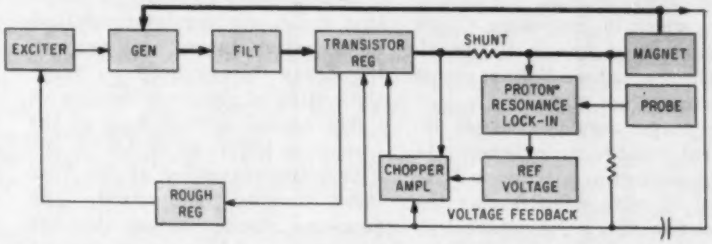


FIG. 1—Regulator parts are connected in double servo loop. Note a-c-coupled voltage feedback path

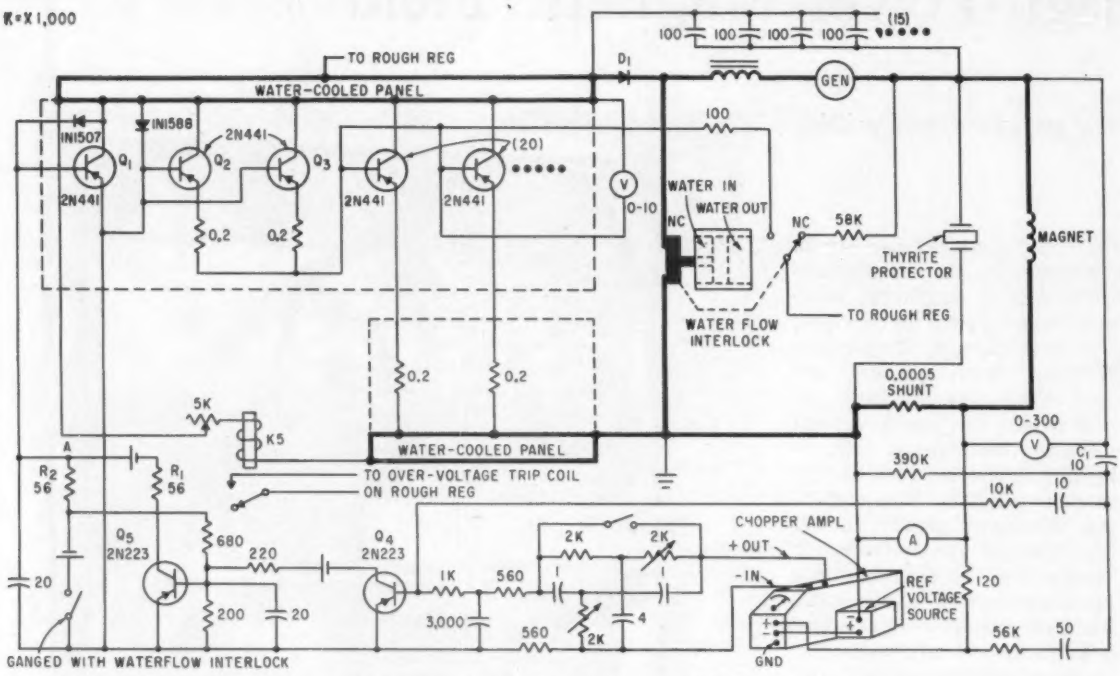


FIG. 2—Fully transistorized fine regulator uses twenty transistors paralleled in output stage

to go more negative with respect to the Q_5 emitter. This potential is applied to the first driver in the power section, causing an increase in collector-emitter current. This current flows through the double drivers which in turn cause a high base current to flow in the paralleled pass transistors. Voltage across transistors drops accordingly.

The rough regulator senses insufficient voltage drop across the pass transistors and begins to drive upward in voltage, increasing the current flow. When the voltage drop across the shunt corresponds to the reference voltage inserted, the null indicator output decreases causing less current to flow in Q_5, more current to flow in Q_4, point A to go less negative and the drivers to decrease base current flow in the pass transistors. Then the voltage drop increases, the rough regulator stops its increase and a final value of base current is reached causing the desired current to flow in the load. Any further increase in current will decrease the null indicator output and thus tends to monitor the current.

Because of time lags in the system, output polarity of the null indicator occasionally goes positive and cuts off the preamplifier on large current changes in the downward direction. At such time the Zener diodes across the driver and pass transistors conduct. To insure that the coarse regulator continue its operation during such periods, the Zener voltage must be above the setting of the coarse regulator.

The overall current gain of the transistor regulator is 1.6×10^7. Fifteen microamperes at the filter input produce full output. The measured chopper output into the regulator is 2.5 $\mu a/\mu v$ giving an overall gain of 40 amperes per microvolt error.

With such tremendous current gain, any leakage through the dielectric of the coupling capacitors across the magnet would decrease the regulator accuracy. This problem is overcome by shunting C_1 with a 390 kilohm resistor.

Further accuracy problems might be the result of stray currents between ground and generator windings or coupling through the power transformer in the null indicator. Grounding at the emitter bus was found to be best in consideration of these problems. This solution also makes the regulator safer to handle since no major part of it is more than a few volts above ground.

Two Zener diodes prevent transistor overload in the event of loss of information from previous stages or extreme current changes. One diode is mounted across Q_1 and the other across the drivers. If, while the system is loaded, the base current to Q_1 disappears or if Q_1 opens, the voltage drop across the pass transistors would rise until they were destroyed. The Zener diodes, however, limit the drop to a value within the transistor rating by clamping the bases to the collectors.

When proper operating information is restored, the diodes cut off and in no way affect regulation. An inadvertent rapid signal to decrease current might cause the voltage-drop-current product to exceed the dissipation rating of the transistors. Zener diodes prevent this situation from developing.

If the drivers or pass transistors open, a relay monitoring the collector emitter potential trips a circuit breaker in the rough regulator and turns the system off by removing generator excitation.

Reverse polarity protection was

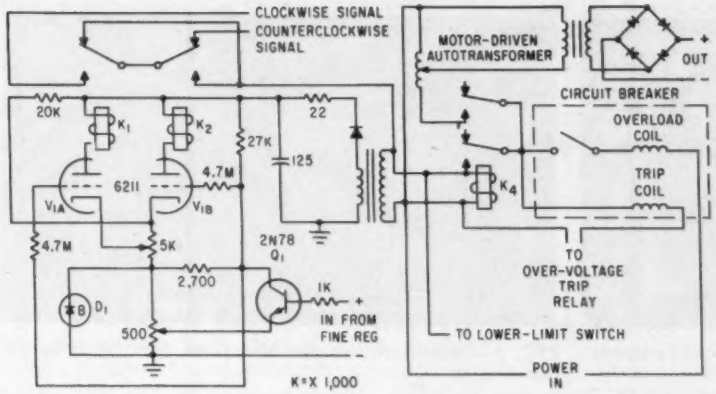


FIG. 3—Rough regulator circuit drives autotransformer to determine narrow range of fine regulator operation

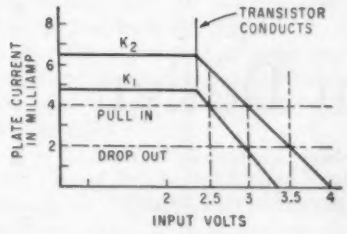


FIG. 4—Relay characteristics provide an operating "window" in the output voltage control. Initially K_1 and K_2 are above pull-in current. At 3 volts, K_1 drops out. If voltage increases, downward correction begins only at 3.5 v and stops at 3.0 v. Similarly, upward correction cannot begin until 3.5 v is reached

added as a precaution against wiring error, since the regulator is connected and disconnected frequently. To accomplish this, a high-current silicon rectifier D_1 is mounted on a water-cooled plate and connected in series with the load.

A pressure differential water-flow interlock bypasses the rectifier and transistors if water flow fails. If the interlock operates, it is necessary to supply the rough regulator with auxiliary information to drive down since the transistor drop is zero. Otherwise, the generator would be driven to full output and apparatus damage might result. Protection is obtained by connecting the input of the rough regulator to the positive terminal of the generator through a dropping resistor when the interlock is closed.

A thyrite resistor is connected across the magnet and shunt. In case of rapid power supply failure, energy stored in the magnetic field dissipates in the resistor. Regulating the current through the resistor would superimpose its characteristics on the magnet current; therefore, the resistor is connected so that the small current which normally flows through it does not appear as a voltage drop at the shunt.

The rough regulator (Fig. 3) uses a combination of a transistor and a vacuum tube to control the output of a motor-driven variable auto-transformer. A potentiometer across Zener diode D_1 in the cathode leg of the circuit establishes the potential about which the regulator operates. Transistor Q_1, which controls the grid voltage of V_1, cannot conduct until input to the regulator exceeds the potential between the emitter and ground.

The motor control relay circuit has been designed to be relatively fail safe. When both relays K_1 and K_2 are de-energized, the motor receives a counter clockwise or drive-down signal. After the tube has warmed-up, K_1 and K_2 pull in and a clockwise signal is established. This drives the voltage up until transistor drop from the fine regulator causes Q_1 to conduct. When this occurs V_{1B} cuts off first, since it is biased more negatively than V_{1A}. Relay K_2 then drops out and the motor stops. Further increase in transistor drop in the fine regulator causes Q_1 to conduct more heavily cutting off V_{1A} dropping out K_1. This is a drive-down signal. The circuit is fail-safe since, if the tube burns out or has not warmed up sufficiently, a counterclockwise signal exists.

For additional safety, the apparatus will not turn on until the variable autotransformer has reached its lower limit. A relay with a holding circuit then turns the electronic and power circuits on. Momentary power failure will initiate a shut-off and run down to zero output before excitation is again provided. The motor control circuit has a fast electrical brake that instantly halts rotation when either turn signal disappears.

In this application the output of the variable auto-transformer is fed into isolation transformers, rectified, and fed to the field of the generator exciter. If a large autotransformer were available, it could be used to supply power directly. It is not necessary to use a 2N78 transistor in this circuit. Any low-cost npn audio transistor is suitable, provided that an applied V_{cc} greater than 20 v will not damage it.

While the system is designed specifically for magnets, the current regulator may be used for other purposes. It is possible to regulate to an absolute value of current by using a precision shunt and a standard voltage reference. The limit of accuracy is then determined by the precision of reference voltage and shunt. Several units have been constructed for filament current control and resistance measurements at high power.

In operation at the Columbia University Nevis Cyclotron, the reference voltage, chopper amplifier, and field control are more than 300 feet from the magnet and generator. The field developed is about 15 kilogauss over 4 cubic feet and showed no measurable drift over several hours. The system has been successfully used to maintain a fixed field continuously for two weeks.

The author wishes to thank Dr. R. L. Garwin for his suggestions and directions on this project.

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(3) R. L. Garwin, D. Hutchinson, S. Penman, and G. Shapiro, *Rev Sci Inst*, **30**, p 105, 1959.

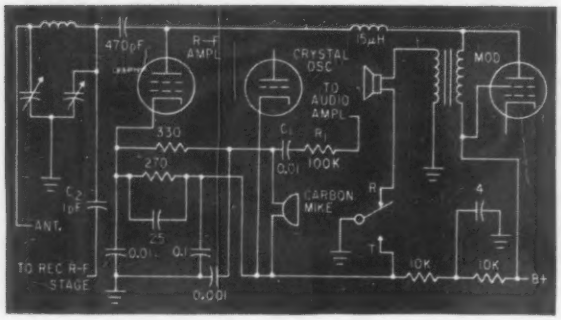


FIG. 1—This circuit eliminates the commonly used transmit-receive relay

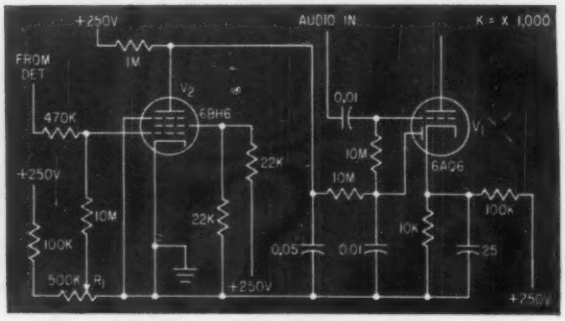


FIG. 2—Squelch circuit operates from negative-going detected signal

Citizens Band Equipment Design

In the two years since the class-D citizens band was opened, transmitter design has remained reasonably constant, while receiver design has varied between the inexpensive superregenerator and the sophisticated dual-conversion superheterodyne. There is a great deal of design similarity, but some new circuits are showing up

By LESLIE SOLOMON,
Associate Editor

THIRTY SEVEN manufacturers sent schematics of their citizens-band equipment in answer to the author's request. Of these 37, there were 8 superregenerator, 8 dual-conversion superheterodyne, 2 transistor superheterodyne and 19 single-conversion superheterodyne receivers.

The superregenerator type is an inexpensive and simple broadband device that is not selective, has poor signal-to-noise ratio and radiates a strong signal during operation. An r-f stage is usually used ahead of this detector to reduce radiation. The current trend is away from the superregenerator, except in the cheaper equipment.

Dual-conversion superheterodynes are used in the more expensive models. Usually, the first i-f is between 4 and 6 Mc with the second i-f about 455 Kc.

The conventional single-conversion superheterodyne is commonly used in citizens-band equipment. The i-f of many receivers appears to be around either 455 Kc or 1,600 Kc. Many receivers offer either crystal-controlled local oscillators, manually controlled local oscillators or a combination of both.

All citizens-band transmitters studied used Heising modulation. This modulation, often called constant-current or choke modulation, automatically limits modulation to 100-percent or less. However, talks with FCC representatives show that some overenthusiastic users are making changes in the modulator, often resulting in illegal overmodulation and citations from the FCC.

The majority of equipment designers are using tried and tested techniques, with some modifications, learned in designing amateur-band and communications equipment. Unlike some amateur-band equipment, citizens-radio gear must be amplitude modulated, crystal controlled within 0.005-percent of the channel frequency and transmitters limited to 5 watts input to the final amplifier.

The bulk of the citizens-band sets were composite transmitter-receiver in one package, usually with a common power supply and audio amplifier-modulator circuit.

Because of the low power, receiving-type tubes are used in both receiver and transmitter. Examination and testing of several units showed low r-f drive to the final amplifier. Good signal (voice) reproduction requires that amplitude distortion should be kept to a minimum. A common cause of distor-

tion is underexcitation of the amplifier when plate modulation is applied. This results in insufficient drive during periods of plate voltage swing and consequent peak output limiting. Besides proper design, some manufacturers are using buffer amplifiers to overcome this objection.

The majority of citizens-band antennas are of the 50-ohm impedance type. Set manufacturers usually make provisions for loading into almost any type antenna by using a pi network as a combination plate tank and antenna-matching network. The pi network can match a tube into a wide variety of load impedances and still maintain the desired value of plate tank circuit Q but the network has impedance matching limitations and will not always efficiently match a tube into any piece of wire.

The bulk of off-frequency violations noted by the FCC have been traced to replacement of transmitter crystals with others of correct frequency but different crystal and holder characteristics.

In many instances, purchasers of citizens-band equipment decide at some later date that they would like to change their operating channel. The FCC rules specify that citizens-band transmitters shall be operated within 0.005-percent of the channel frequency. At 27 Mc, this means within ±1.3 Kc.

Crystals for citizens-band channels can be purchased in a great variety of holders. Among the factors that determine crystal frequency is the capacitance of the holder.

Crystal plates are cut for a specific frequency and are not guaranteed to oscillate at this frequency in any oscillator other than the one used to calibrate the crystal (or a close duplicate). Depending on the crystal oscillator circuit parameters, at 27 Mc, a change in only a few pF can cause off-frequency operation. Crystals should be replaced only with those of the same type, especially where half-frequency crystals are used.

Some manufacturers use an adjustable trimmer capacitor across the crystal to obtain exact frequency. However, the law states that a commercial radio operators license of the proper grade is required for any adjustment of a citizens-radio transmitter during installation, testing or servicing which may cause the transmitter to operate off frequency.

Many manufacturers of citizens-band equipment are using new circuit designs. Among these is an Apelco design that eliminates the commonly used transmit-receive relay. A simplified schematic is shown in Fig. 1.

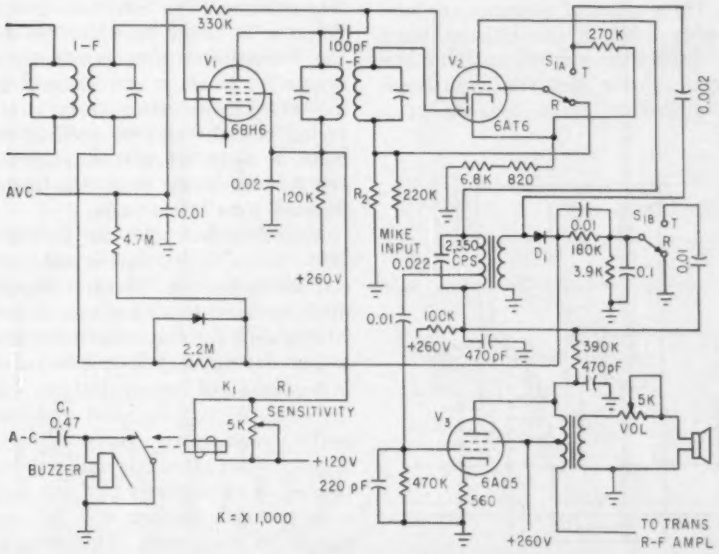


FIG. 3—Simplified schematic of tone-operated calling system operating at 2,350 cps

When the switch is placed in the transmit position, plate voltage of the receiver local oscillator is removed, the loudspeaker is removed from the audio amplifier output transformer secondary and the cathode circuits of the transmitter crystal oscillator and r-f amplifier are completed to ground, thus placing these stages in operation. The carbon microphone receives power from current flowing in the r-f amplifier cathode circuit. Audio signals are then passed through coupling capacitor C_1 and resistor R_1 to the first audio amplifier (in parallel with the signal from the rereiver detector). The output of the last audio stage Heising-modulates the transmitter.

During transmission, r-f enters the receiver through coupling capacitor C_2 and is fed to the receiver r-f amplifier (12AU6), which acts as both r-f amplifier and electronic transmit-receive switch. The r-f signal drives the control grid into grid current and the rectified current biases the r-f amplifier so that it passes little power to the receiver. This bias is also fed up the avc line to cut off the i-f amplifier during transmit.

During reception, the plate voltage is reapplied to the receiver local oscillator, the loudspeaker is replaced in the receiver audio output transformer secondary and a positive voltage is applied to the cathodes of the transmitter crystal oscillator and r-f amplifier, thus cutting them off.

Several interesting noise suppressor and squelch circuits have made an appearance in newer models. A typical squelch circuit, as used by Vocaline, is shown in simplified form in Fig. 2.

First audio amplifier V_1 has a large positive potential applied to its cathode. Due to circuit parameters, the voltage at V_1 diode plate is less than the cathode voltage and since the control grid is returned to this diode plate, V_1 is cutoff.

When a negative-going signal is received from the receiver detector, the control grid of squelch tube V_2 goes negative until the positive bias set by squelch control R_1 is overcome. When the signal overcomes this bias the plate voltage of V_2 rises. This voltage is applied to

V_1 diode plate and increases until diode contact potential is reached. The control grid will then approach the cathode bias and V_1 will come out of cutoff thus amplifying the audio signal applied to its control grid.

A tone-operated calling system using 2,350 cps as the calling frequency is used in Radson units. A simplified schematic of this circuit is shown in Fig. 3.

During reception, switch S_1 is in the position shown. Incoming signals are amplified by i-f amplifier V_1 and detected by one diode of V_2. The other diode is used as the avc rectifier.

The 2,350-cps calling frequency is greatly amplified by the resonant circuit in the plate load of V_2. Diode D_1 rectifies this signal and applies the positive-going voltage to the control grid of last i-f amplifier V_1. As the control grid of V_1 goes positive, increased plate and screen grid current flows through the coil of relay K_1, which forms part of the load. When K_1 operates, it removes the short circuit that its normally closed contacts makes across the buzzer coil. The buzzer receives its operating power from an a-c source through capacitor C_1. When K_1 operates, the buzzer sounds. Sensitivity of K_1 is determined by adjustment of R_1 in parallel with the coil of K_1.

To call a station, pushbutton S_1 is placed in T position to convert the audio stages into a 2,350-cps audio oscillator, which in turn modulates the transmitter with the calling tone.

In the actual circuit, a noise limiter is connected in place of resistor R_2.

The little publicized limited radiation regulation of Part 15 of the FCC rules permits unlicensed operation in the class-D citizens band if the transmitter power input does not exceed 100 mw and the antenna length does not exceed 60 inches. In urban areas, range of such a transmitter can be approximately ½ mile and in the open country about double this range, depending on the height of the unit above intervening terrain and obstructions.

To take advantage of both this no-license regulation and of transistor circuits having small size and low power requirements, several companies are manufacturing all transistor units.

A typical unit designed by Texas Instruments Incorporated is shown in Fig. 4. This three transistor transceiver has 30 mw r-f output and a range of a few thousand feet.

The detector uses a 40 Kc quench frequency and has a sensitivity of 2 μv for a 10 db signal-to-noise ratio. It uses 15 ma during receive and 30 ma while transmitting. The loudspeaker is used as a microphone in the transmit condition.

Other manufacturers are making transistorized units with some transmitters having r-f power amplifiers with inputs up to the legal maximum of 5 watts.

Three types of antennas are commonly used in the citizens band. These are the vertical ground plane, vertical whip and Yagi-type beam. The ground plane consists of a vertical quarter-wave section operated against three or more ground-plane rods. Some manufacturers are now mounting another set of ground plane rods below the first set to lower the radiation angle. This type of antenna is omnidirectional.

The vertical whip is used in almost all mobile installations. It usually consists of a quarter-wave section that uses the body as a ground plane. Proper length for the citizens band is approximately 100 in., but some manufacturers use loading coils to reduce the physical size of the whip. One company, Mark Products, markets a continuously loaded whip that uses a variable pitch winding around a glass fiber rod as a radiator. The overall length of this antenna is about 4 ft.

As the number of citizens band transmitters in operation increases, interference becomes a problem. A growing number of users are turning to the Yagi-type antenna for point-to-point communications. A typical Yagi-type antenna, manufactured by Mosley is a three-element beam using a half-wave dipole. This antenna has a gain of approximately 8 db over a ground plane resulting in a power gain of about 7. A beam antenna at each end of the communications circuit results in a 16 db signal increase since the gain applies to receiving as well as transmitting. The effective power increase is about 40 which makes the 5-watt maximum power limit equivalent to about 200 watts. Signal strength reduction from interfering stations may be reduced as much as 25 db when these stations are located away from the main forward lobe of the beam.

According to F.C.C. SS Bulletin 1001c issued by the Safety and Special Radio Services Bureau, beginning January 1, 1961 a new letter will be used for the serial numbers issued during each calendar year.

A series of seven letters (Q through W) will be used and repeated each seven years. Every license issued after this date will be treated as a completely new one and a new serial number will be assigned in each case. This means that modified and renewed licenses will carry a new serial number.

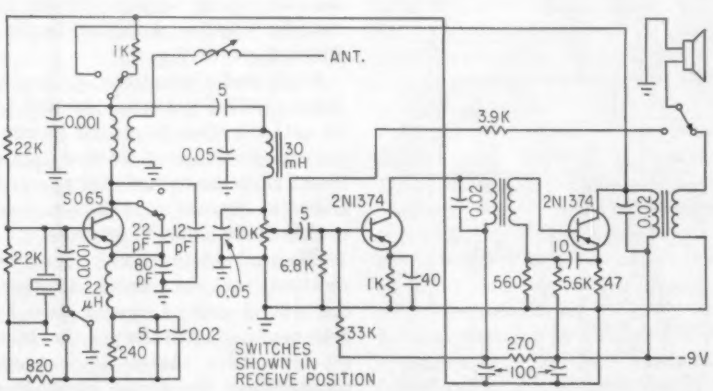


FIG. 4—Three transistor transceiver permits unlicensed operation under the limited radiation regulation

AN ECONOMICAL

Multiplier for Analog Computers

This multiplier uses an operational amplifier in a new circuit configuration. One input variable controls the amplitude of the multiplier's output pulses and the other variable controls their duration. The amplitude-time product of these pulses corresponds to product of the input variables

By A. J. FERRARO,
Department of Electrical Engineering, The Pennsylvania State University, University Park, Pa.

MANY of the smaller electronic computers have no way to generate the product of two time-varying quantities; this limits the scope of problems that can be investigated. Although there are excellent multipliers, recent designs are complex. Many methods are available for forming the product of two variables but, not all are practical[1] or they are limited to small signal operating conditions.

This multiplier can be adapted to any analog machine by adding only two tubes that are used with one of the operational amplifiers of the computer. This permits set up of a multiplier as easy as set up of an integrator or adder built around an operational amplifier, that is, by connecting an active element in the feedback path.

Pulse-amplitude and pulse-width modulation are used to form the product. In the sequence of rectangular pulses shown in Figure 1A. The average voltage, V_{d-c}, is proportional to the area enclosed by the pulse $V_{d-c} = VT/T_o$. The amplitude is controlled by variable Y, and the pulse-duration is dependent upon another variable X. Then $V = K_1Y$ and $T = K_2X$. Thus

$$V_{d-c} = (K_1 K_2/T_o)\, XY \text{ or } CXY$$

If X and Y are functions of time, the amplitude and width are also time dependent; this is shown schematically in Fig. 1B. The product can be recovered by passing these pulses through a low-pass filter that rejects other frequency components.[2]

The multiplier shown in Fig. 2A incorporates this technique. The amplitude modulator is an electronic switch. Signal Y is sampled whenever the switch is closed, and closure occurs if the generator produces a pulse. Length of sampling depends upon the amplitude of X; hence, output of the switch is a variable-area rectangular pulse.

The amplitude modulator is built around a high-gain amplifier used as an operational amplifier. The gain must be high so that the transfer function is determined mainly by the feedback network. In Fig. 2B, a dual triode, V_1, which is in the upper feedback path, is opened or closed depending upon the polarity of E_{sw}. When E_{sw} is positive one section of the tube conducts, making $E_o \sim E_{o1}$. For a high-gain amplifi-

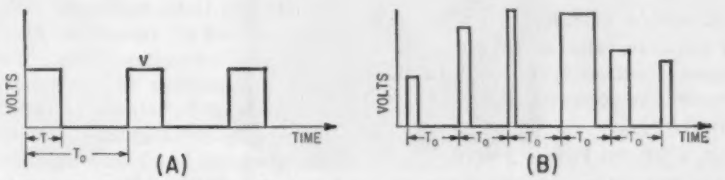
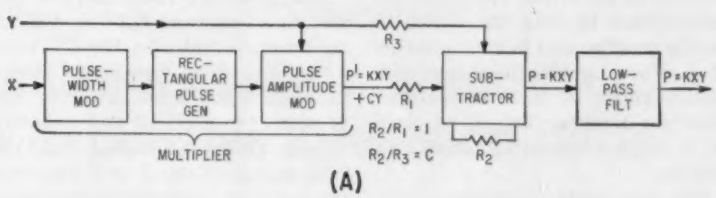


FIG. 1—Average voltage of a pulse is proportional to its area (A). Combined amplitude-width modulation (B)



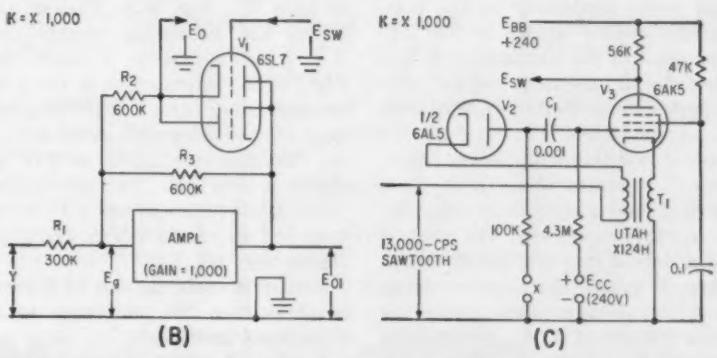


FIG. 2—The subtractor eliminates CY, the undesired term of the multiplier's output (A). Multiplier comprises pulse-amplitude modulator (B) and rectangular-pulse generator and pulse-width modulator (C)

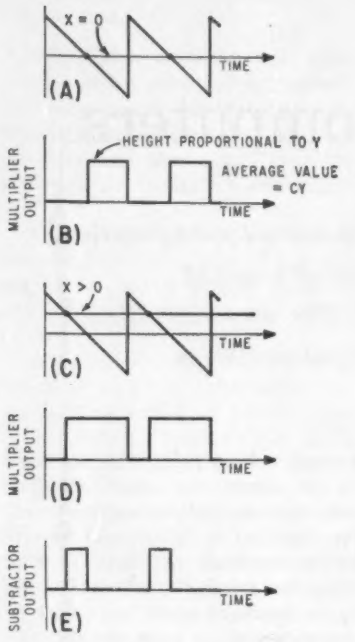


FIG. 3—Waveforms for positive X and Y inputs

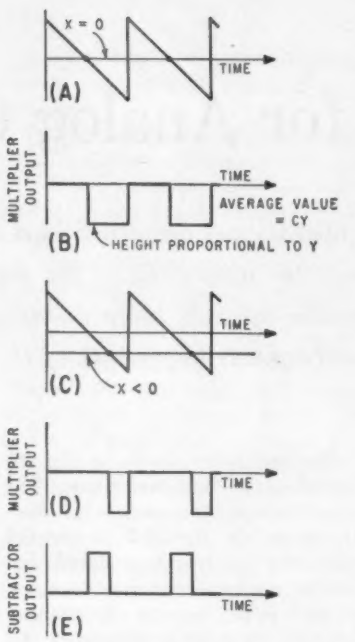


FIG. 4—Waveforms for negative X and Y inputs

er output voltage E_o is

$$E_o = E_{o1} = -[R_2 R_3/R_1 (R_2 + R_3)] Y$$

A negative value of E_{o1} opens the upper feedback path, making E_o assume the potential of E_g which is given by

$$E_g = [(R_3/R_1) Y]/[1 - A + (R_3/R_1)]$$

This expression approaches zero for a high A (forward gain). The two sections of the triode are connected back-to-back to allow the switch to handle positive and negative values of Y. For example, the upper tube section conducts if Y is positive, since the amplifier brings its plate to a higher potential than its cathode.

The rectangular pulse generator and width modulator is the comparator circuit[3] shown in Fig. 2C. The input of the comparator is supplied by a sawtooth signal with negative slope. Before diode V_2 conducts, the plate voltage of V_3 is low since it is conducting heavily; however, V_2 conducts whenever the sawtooth voltage equals X. If capacitor C_1 discharges slightly, the grid of V_3 is driven into the cutoff region when X equals the negative-going sawtooth voltage. This forces the plate voltage of V_3 to rise rapidly towards E_{bb}. Pulse transformer, T_1 provides regenerative feedback so that the time to cutoff V_3 is small. Grid cutoff continues until the sawtooth returns to its maximum positive value, and E_{cc} causes the plate to resume a low-voltage state. The process is repetitive, the waveform at the plate of V_3 being a series of pulses nearly rectangular in shape. If the sawtooth is a linear function of time, the width of these pulses is proportional to the variable X.

The product P' at multiplier output E_o is equal to $KXY + CY$. A subtractor eliminates the CY term (Fig. 2A). The waveforms shown in Figs. 3 and 4 indicate how this is done for positive and negative X and Y inputs. In Fig. 3A, the intersection of the $X = 0$ line with the sawtooth is the triggering point of tube V_2 (Fig. 2C). Figure 3B shows the multiplier output for $X = 0$ and a positive Y input. In Fig. 3C, the intersection of the line corresponding to an X input greater than 0 is the triggering point of V_2; the resulting multiplier output is shown in Fig. 3D. The subtractor (Fig. 2A) removes the CY term from the waveform in Fig. 3D, producing Fig. 3E.

Similar waveforms can be drawn to show that the multiplier is a 4-quadrant multiplier.

Product P, which is contained in the pdm and pam signal, is recovered by demodulation of the signal. A convenient system of demodulation requires a low-pass filter. Design of a filter is dependent upon the use of the multiplier; in some applications little or no filtering is required. If the output of the multiplier is recorded by a mechanical device, no filter would be required. However, when the solution is displayed on a cro, a sizable amount of filtering is desirable. An R-C filter with a cutoff of 1,000 cps was sufficient when using a sawtooth of 13,000 cps for the comparator input.

Static and dynamic tests provide data for studying the operation and usefulness of the multiplier. Normally the errors present are determined from the static test, and the frequency range found by dynamic methods. Application of manually controlled d-c voltages to the X and Y inputs supplies the information for static characteristics. Several tests were performed with Y fixed and X as the independent variable; a family of curves displaying this product as a function of X with Y as a parameter determines the static characteristics. These data showed an error less than 2 percent of full-scale output. Dynamic tests show that frequencies as high as 150 cps give satisfactory results with about 10 deg phase shift.

Figure 5 displays the product of $X = 1 + \sin(2\pi)60t$ and $Y = \sin(2\pi)600t$, the waveform of a 100-percent amplitude-modulated carrier of 600 cps.

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(3) B. Chance, V. Hughes, E. MacNichohol, D. Sayre and F. Williams, "Waveforms", p 343, McGraw-Hill Book Co., N. Y., 1949.

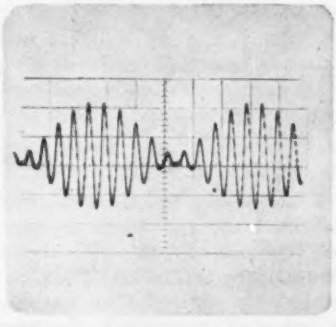
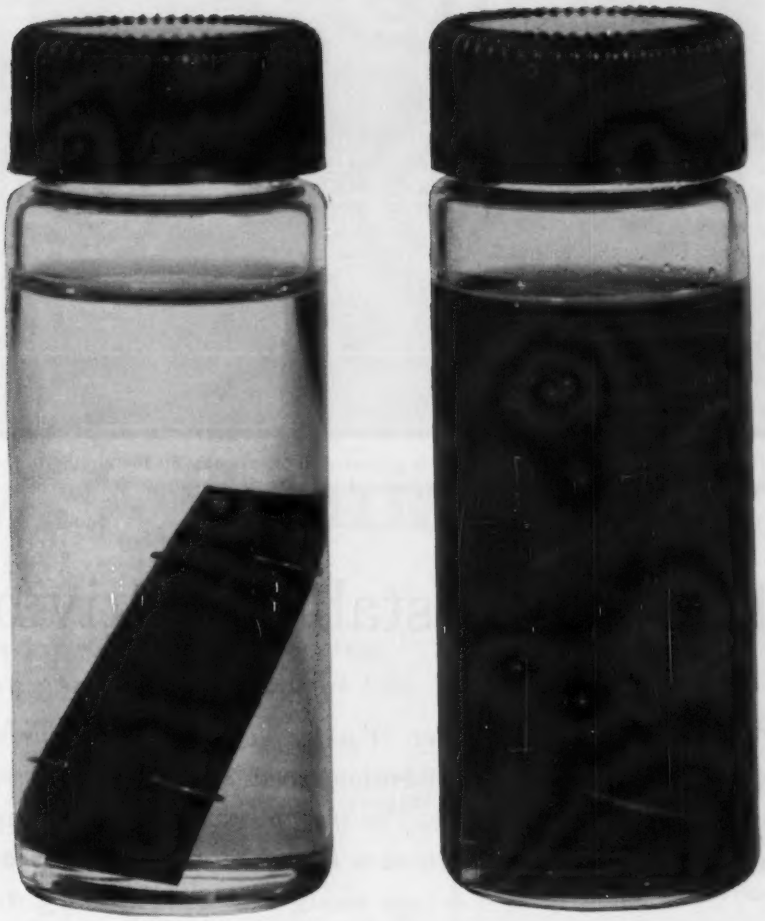


FIG. 5—Waveshape shows product of a 600-cps carrier and a 60-cps modulating wave



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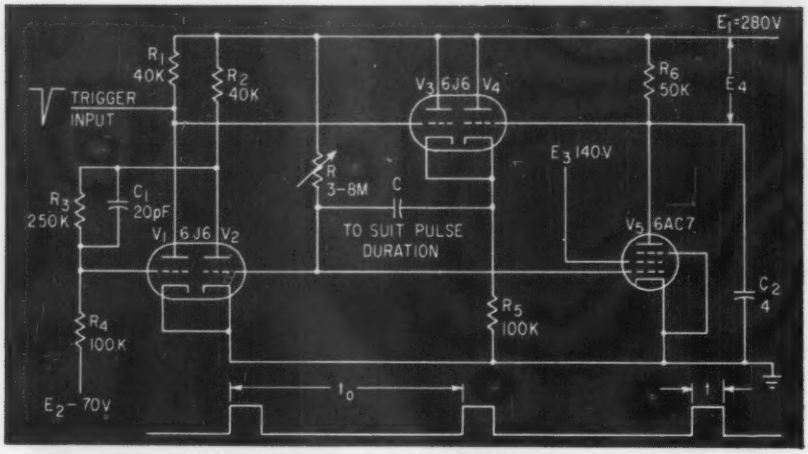

Average plate voltage of pentode V_5 is adjusted automatically by the circuit to maintain optimum working conditions throughout the circuit operating range

Stabilizing Monostable Multivibrators

Operating as a 10:1 divider at a frequency of 1,000 pps, the division ratio of this multivibrator remains constant for supply variations of 40 to 400 volts. The timing resistor can also change from 3 to 8 megohms without a deterioration in performance

By TOMAS HORNAK,
Tesla Company,
Prague, Czechoslovakia

THE MULTIVIBRATOR formed by triodes V_1 and V_2 is designed for frequency division at high values of division ratio (up to 25:1) and for maximum stability of this ratio against variations in supply voltage and other circuit parameters. However, the stability of the circuit acts in opposition to the desired effect if the input frequency drifts, in which event the pulse-width remains constant but the division ratio varies with this input frequency.

The grid of tube V_3 is connected to grid of V_2 making tube V_3 conducting, simultaneously with V_2, during the quiescent state only. The time constant R_6C_2 is substantially larger than the period of a complete cycle and therefore the volt drop across resistor R_6 develops a voltage proportional to the average current of tube V_3. Denoting the plate current of V_3 during conduction by i, the voltage drop E_4 is

$$E_4 = R_6\, i\, (t_0 - t)/t_0$$

Where t is the pulse width and t_0 the interval between inputs

In parallel with the cathode follower V_3 is a second cathode follower V_4 having its grid connected to the plate of V_5. Thus, however small the grid voltage of V_2 might be, the voltage at common cathode of V_2 and V_4 cannot decrease below the grid voltage of V_4. Therefore tubes V_2 and V_4 form a controlled limiter, limiting the voltage step ΔE on the R-C network to a value $\Delta E \doteq E_4$. For simplification of further calculations consider $\Delta E = E_4$.

From the circuit diagram the relation between the pulse duration and the circuit parameters is given by

$$t = RC \ln (\Delta E + E_1)/E_1$$

Substituting $\Delta E = E_4$ and replacing the logarithm by the first member of the logarithm's series expansion gives

$$t = RC\, E_4/E_1$$

Substituting for E_4

$$t = RC\, R_6\, i\, (t_0 - t)/E_1\, t_0$$
$$= (RC\, R_6\, i/E_1)/(1 + RC\, R_6/E_1\, t_0)$$

Differentiation gives the relation between the relative variation of pulse duration and the relative variation of the time constant

$$\frac{dt}{t} = \frac{t_0 - t}{t_0}\,\frac{d(RC)}{RC}$$

Similar relations are valid for relative variations of other parameters (i, R_6, E_1) as well. When t approaches t_0, the stabilization factor increases infinitely.

The calculation contains several inaccuracies, which however, do not distort the qualitative illustration of the circuit properties.

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(2) Chance, "Waveforms," 5.5, McGraw-Hill Company, New York, 1949.
(3) Luther, Stabilization of Pulse Duration in Monostable Multivibrators, RCA Review, Sep., p. 403, 1955.

Microwave Component News
from SYLVANIA

Lower relay equipment operating costs with new Sylvania Klystrons

Metallurgical and processing improvements mean superior life and performance

Sylvania's research and production capabilities have produced a series of klystrons that promise to surpass earlier types in performance.

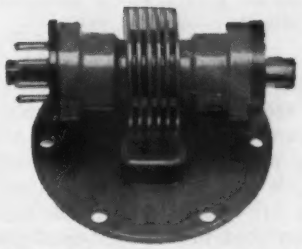
Sylvania's klystrons have the following features:

Improved high-temperature glass seal— this permits higher bake-out temperatures and gives a lower gas level. The resulting tubes have a life expectancy of 10,000 hours, 2,000 hours longer than competitive types, and better shelf life. This means lower operating costs for relay link equipment.

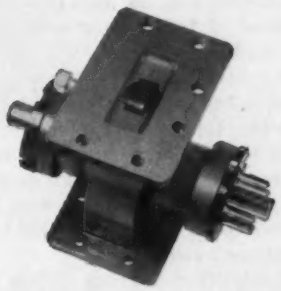
Purer metals and materials – the premium quality metals used in these tubes, combined with new, exacting processing techniques permit higher bake-out temperatures and result in longer trouble-free operation with low gas levels.

Superior performance – full coverage from 5925 to 8100 mc with 1 watt nominal output power. Most of these tubes have a minimum electronic bandwidth of 28 mc.

Sylvania klystrons will give you added cost savings because of their longer life and fewer early-life failures. Send for the data.



SK-220B, shown approx. ⅓ actual size. Fins facilitate forced-air cooling.



SK-222D, shown approx. ½ actual size. Flange connects to heat sink.

Forced air cooled	Conduction cooled	Frequency
SK-220F	SK-222F	5925-6225 mc
SK-220E	SK-222E	6125-6425 mc
SK-220G	SK-222G	6425-6575 mc
SK-220D	SK-222D	6575-6875 mc
SK-220C	SK-222C	6875-7125 mc
SK-220B	SK-222B	7125-7425 mc
SK-220A	SK-222A	7425-7750 mc
SK-220Z	SK-222Z	7750-8100 mc

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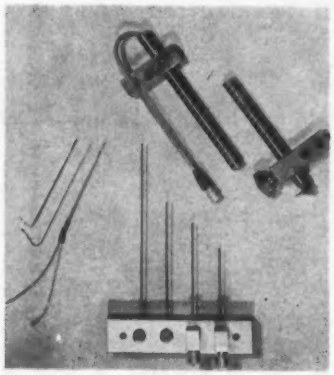
System Measures Shock-Front Velocities



Close dimensional tolerances of probes, which are available in a wide range of sizes and in four types, are basic factor in accuracy of velocity-measuring system

ACCURATE velocity measurements of the shock fronts of gases compressed by rocket propellants are being made in a research project. A wide variety of other applications are possible with the type system used in these experiments. As well as gas and liquid shock-front velocities, the shapes of the wave fronts can be detected, and the speed of fast-moving solid objects can be determined.

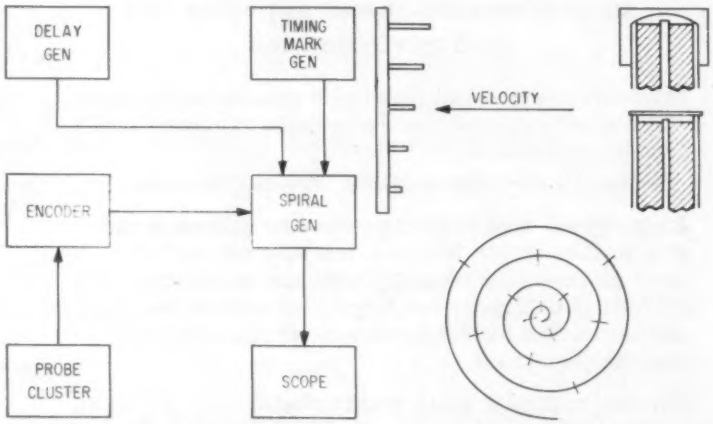
The developmental measuring system is applicable in locations inaccessible for photographic techniques, such as in monitoring phenomena associated with high explosives. Total cost of the system is expected to be lower than that of conventional methods.

The velocity-measuring system is being developed by Research Products Associates, Stamford, Conn., which also produces the velocity-sensing probes on which the system is based. Thiokol Chemical, Brigham City, Utah, is presently using the RPA probes in pressure-wave velocity measurements associated with rocket propellants.

The sensing element shown in the photograph comprises a cluster of coaxial probes that function as fast-acting switches. Length of each probe in the group is different, and the probes are directed opposite to the velocity vector as shown in the drawing. A sudden increase in gas or liquid pressure, a solid object or a conductive medium closes the probes in the cluster sequentially. Time between closure of the circuits involving individual probes and their known difference in length permit determination of velocity. Times that each probe in the cluster completes a circuit are displayed on a cathode-ray tube as pips on a spiral sweep. However, a variety of other instrumentation setups could also be used.

Four basic types of probes are being produced in a variety of sizes for different applications, some of which are shown in the photograph. Cross sections of the cap and the diaphram types are shown in the drawing. Increases in gas or liquid pressure or a fast-moving solid object cause the conducting diaphram or cap that is in contact with the outer conductor to complete a circuit to the center conductor. The circuit through an exposed center conductor is completed by a conductive medium in a third variation, with a fourth probe designed for ionized gases.

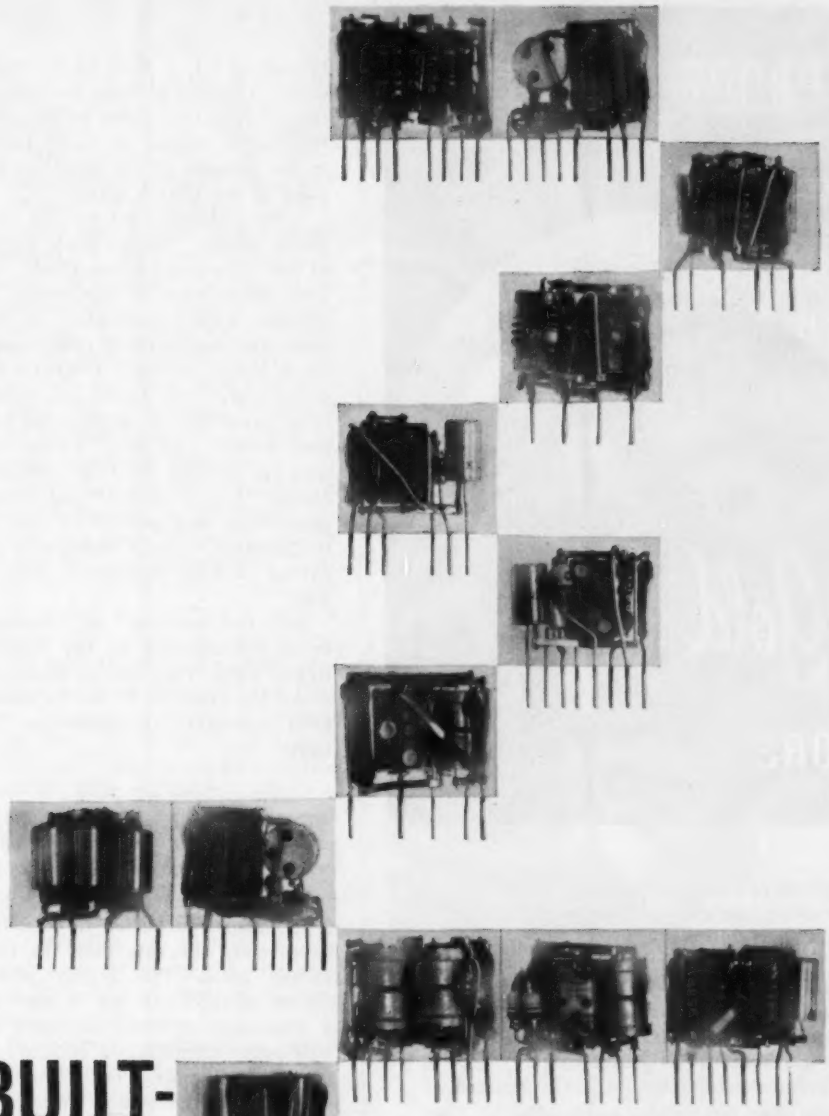
Probe diameters presently range from 1/100 to ¼ inch although other sizes are planned for specific applications. Smaller diameters like those at the left of the photograph are used where probes might interfere with the shock front or alter velocity of a solid object. In the latter case, the probes are considered expendable. Different lengths of the same type and diameter probes are produced, with length being one of the dimensions held to very close tolerance for system accuracy. Because of these tolerances, the probes are being fabricated on precision Swiss automatic screw machines. A probe board used in the system functions as an encoder providing pulses when the circuit involving each probe is completed. Pulse characteristics such as shape, duration and polarity enable indentification on the display of the particular probe that has been switched.



Probe cluster provides encoded pulses for spiral display shown at lower right with timing marks. Capped and diaphragm type probes shown in cross sectional view at upper right are mounted in clusters like that to their left directed opposite to the velocity vector

The spiral sweep generator in the block diagram is triggered by the delayed-firing generator, which can also be used to trigger the event to be monitored. Alternately, an additional probe mounted closer to the source of activity could be used to trigger the spiral generator.

The timing marks shown on the spiral in the illustration are produced by another generator at in-



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tervals of 0.1, 1, 5 or 10 microseconds. Circuits provide voltages to the crt deflection plates so that timing marks appear at right angles to the tangent of the spiral at the point of the timing mark.

Several factors led to use of a spiral sweep. Sweep time begins at the outer edge of the spiral. As time after start of the sweep increases, time increments on the trace are progressively compressed. As a result, all time intervals beginning with the sweep and within total sweep time have the same percent error. The spiral sweep also uses the circular crt face more efficiently than a conventional raster permitting long periods of time to be displayed without loss of data occuring during horizontal retrace time.

Information can be obtained from photographs of the display in two ways. Time can be measured along the trace or it can be measured angularly to determine velocity.

Free-Atom Maser Emits Precise 21-Cm Wave

FREQUENCY of emission from a new type maser is expected to be many times more accurate than the best atomic clock. The highly stable source of radiation can be used as a frequency or time standard as well as an amplifier. In addition to its potential application in practical equipment, the new atom maser will enable scientists to perform a wide variety of experiments.

The three Harvard scientists who developed the atomic maser expect wavelength of the 21-cm radiation from it to be accurate within one part in 10^{15}, which is 10^5 times that of the most accurate atomic clock in operation. Presently, lack of a standard prevents accuracy from being tested, but performance will be compared with that of a second atomic maser now being constructed.

Key to precision of the maser is use of free hydrogen atoms, rather than atoms bound in molecules or crystals. When energy level is changed, interactions of atoms in molecules or crystals causes some spreading in the frequency of radia-

tion. However, these interactions do not occur with free atoms so that radiation is released at precisely the same wavelength.

Use of free hydrogen atoms was made possible by a device called a bouncing box in which atoms at the high-energy level are temporarily stored. In operation, a stream of hydrogen atoms is passed through a magnetic field that reflects atoms at the high-energy state into the box. Since radiation from hydrogen is weak, the atoms must be stored until enough have accumulated to release detectable radiation.

Hydrogen atoms bouncing off the sides of the box would usually interact with the surface and rapidly drop to the lower energy level. However, the bouncing box is a quartz bulb coated on the inside with a paraffin that does not readily interact with the bouncing atoms. Experiments have demonstrated that one high-energy level hydrogen atom can endure at least 10,000 collisions in the storage unit—a life time of about one second.

Operating as an oscillator, the maser will be used to measure some physical properties of protons, electrons and neutrons in atoms much more accurately than has been possible. Studies are planned of the interaction between the nucleous and its orbiting electron in deutrium and tritium.

In another experiment, an excess of hydrogen atoms will be deliberately forced into the storage box to study and measure interactions among them. These kind of interactions occur in the clouds of hydrogen in and between galaxies, emitting the 21-cm radiation detected by radio telescopes. The maser could also be used to measure more precisely the effects of gravity and velocity on time, which was predicted by Einstein.

The atomic maser might eventually be used in long-range communications. Such an amplifier in an earth satellite could be used to bounce signals from earth to another point. Because radiation frequency is so precise, range could be extremely long.

The free hydrogen atom maser was sponsored by the National Science Foundation and the Office of Naval Research.

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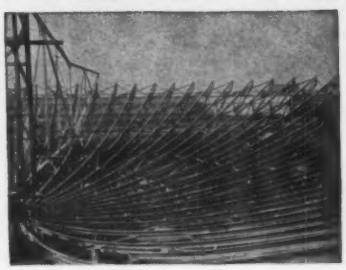
Radar Reflector Uses Honeycomb Panels

By ROY A. HUNDLEY*
WILLIAM SPONT†
Western Development Laboratories
Philco Corporation, Palo Alto, Calif.

THE TELEMETRY AND DATA acquisition antenna now in service at Vandenberg Air Force Base is not only claimed as one of the largest three-axis antennas, but it also incorporates one of the largest solid-surface reflectors that supports an r-f reflective mesh. Designed and developed by Philco Western Development Laboratories under contract to the Lockheed Missiles and Space Division, Sunnyvale, Calif., the reflector is a paraboloidal surface 60 ft. in diameter. It has a focal length of 25 ft.; a depth of 9 ft.; and weighs 15,000 lbs. The 216 reflective panels, weighing 3,300 lbs., are made of reinforced plastic honeycomb construction. These compound curvature panels are wedge-shaped and range in size from 2 ft. wide up to 9 ft. in length and 3 ft. by 8 ft. The panels, after fabrication, are attached to an aluminum ribbed skeleton aircraft-type framework. The support surface of the reflector dish and the panels themselves are divided to 5 degree segments at the outer rim and to 10 degrees at the center of the dish.

*—Manager, Electro-Mechanical Equipment Department
†—Engineer



Three-axis-mounted antenna (top left) built by Philco's Western Development Laboratories, Palo Alto, Calif., for the U. S. Air Force, will be used to receive telemetered data from satellites and missiles. Reflector surface of antenna (top right) consists of 216 reinforced plastic honeycomb panels produced by Dumont Manufacturing Corp., San Rafael, Calif. Electrical continuity of the reflector surface is provided by aluminum doubler plates connecting the aluminum screen embedded into the surface of the panels. Honeycomb panels are attached to this supporting network of aluminum I-beams (bottom left) which were stretch-formed to a curve ⅛-in. below the equation of the parabola. The 60-ft diameter, 15-ton reflector was hoisted atop the 50-ft tower by two 70-ton cranes (bottom right)

Honeycomb panels were chosen to assure accurate surface contours. Contour accuracy of the reflective surface, checked by 2,880 separate readings of a sweep template set up at the apex of the reflector and free to rotate 360 degrees above the dish surface, shows that the entire surface area does not deviate more than plus or minus $\frac{1}{32}$-in., while the rms value was ± 0.036-in. over the 3,000 sq. ft. of reflector surface. Considering surface size and the number of individual sandwich panels which were fitted together to form a parabolic dish, the results are exceptional for so large a reflector.

Another advantage inherent in honeycomb sandwich panel construction is that high strength-to-weight ratios can be obtained economically, without incurring the costs of expensive structures normally required to take high wind loading. Even with maximum operational wind loading, the honeycomb panels deflect at their centers less than $\frac{1}{16}$-in, tolerances which call for ± $\frac{1}{16}$-in.

Antennas of this type may be installed in areas where ice and snow will be encountered; merely tipping the dish will cause the snow and ice to slide off.

The 216 honeycomb sandwich panels were constructed with contour curve tolerances of ± 0.032-in. within the face of any one panel; assembled for electrical continuity from panel to panel; and with minimum solar reflection off the panel faces.

The Dumont Manufacturing Corp. a subsidiary of the Dutron Corp., San Rafael, Calif., fabricated the panels for Philco and chose tooling techniques and manufacturing processes required to ensure the maximum accuracy.

Each sandwich panel, ⅝-in. thick, consists of an aluminum honeycomb core to which reinforced plastic skins are bonded on both sides. The skins are made up of three layers of 181 glass cloth impregnated with epoxy resin, chosen for weathering properties, high adhesive strength

Photo: Courtesy Westinghouse Air Arm Division

Congratulations!

to WESTINGHOUSE for an exciting breakthrough.

A RADAR RECEIVER NOISE FIGURE of 2.8 db at an X-band operating frequency has been achieved by engineers of the Westinghouse Air Arm Division. Dr. Robert Rampolla (left), and Mr. Thomas Hollis (right), using a true non-degenerate X-band parametric amplifier and a Microwave Associates "pill" varactor (MA-4253), achieved a 20 db gain with excellent stability and ample bandwidth.

This remarkable accomplishment in low-noise amplification at X-band resulted from research on a program sponsored jointly by Westinghouse and the U. S. Navy.

Sophisticated Varactor technology at Microwave Associates which made these results possible has produced the most complete line available of advanced varactors in standard, miniature "pill", and glass packages.

Write for detailed information and performance data on varactor techniques.

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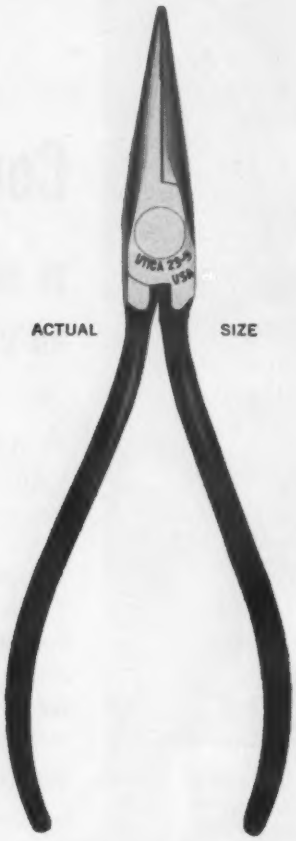

ACTUAL SIZE

NEW MIDGET CHAIN NOSE!

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Utica Drop Forge & Tool Division, Kelsey-Hayes Company, Utica 4, N. Y.

tools the experts use!

and low shrinkage.

To prevent warpage and distortion resulting from the molding process, mesh was embedded into the convex side of each panel; and also on the concave side to provide a reflective surface and electrical continuity.

Without adequate protection, the parabolic surface of the reflector would act as a solar furnace. This cremation of the feed horn was avoided by minimizing heat reflectivity in two ways: a) by embedding aluminum mesh into the concave face of the reinforced epoxy skin so that the screen on the surface created an irregular, nonreflecting pattern; and b) coating the concave surface of the skin with a dull black epoxy paint. The combination of mesh pattern and paint lowered heat reflection to less than 1% of energy absorbed.

The reflector was assembled in an inflatable plastic dome 85-ft in diameter and 40-ft high.

By erecting the dome over the framework, temperature inside the dome was held to within 5 to 10 degrees of 75 F. On reassembly of a reflector, however, the dome is not required. The antenna shipped to Vandenberg AFB was completely reassembled with full accuracy in just 4½ days.

The structure supporting the reflective panels consists of an aluminum I-beam which is stretch-formed to a curve that is ⅜-in. below the equation of the parabola. The I-beam forms the upper rail of a truss composed of a space lattice. There are 72 such ribs in the truss, all of them tied together with an aluminum tube to produce a tetrahedral lacing design.

All panels are connected to produce electrical continuity throughout the reflective surface. Some of the panels are bolted so that they can be removed to permit entry into the reflector for servicing.

New Insulating Tape For Wrapping Motor Coils

A NEW INSULATION for electrical equipment, transformers and motor coils, has been developed by International Resistance Co.'s Plastic Products Division.

The tape, known as Lamoflex Type TG, is constructed of Teflon

FEP on one side of a glass cloth reinforcement. Both the thickness of the Teflon and the type of glass cloth may be varied.

The first series to go into production has 0.002 inch Teflon FEP on 0.002-in. glass cloth. Available in widths from one-half in. to 6 in., a typical quantity price is $14.47 per 36-yard roll in the 1-in. width.

One of its prime uses, according to Fred Delnevo, Marketing Manager of the Division, is in the wrapping of motor coils.

In one application, the preformed diamond-shaped copper coil is wrapped with tape using a half lap with the FEP side facing the copper. The starting end and the end of the wrap may be tacked with a silicone resin if desired. The wrapped coil can then be either impregnated with a silicone resin and baked or the FEP can be fused to itself using an oven heated to 300 C or an induction coil.

Using another method, straight copper bars can be wrapped, using a half lap, with the FEP facing the copper. During wrapping, the bar can be run through an induction heater, fusing the Teflon FEP to itself. The insulated coil can then be formed to shape.

Thermocouples for Low Temperature Application

A NEW LINE of gold-cobalt vs. copper thermocouples and complementary indicating, recording and controlling instruments for low temperature applications has been announced by Cryogenics, Inc., Washington, D. C.

Open and closed well thermocouples are available in ranges from 0-300 K, with accuracy of ± 1 per cent of span or 2 K, whichever is greater. All are interchangeable to ± 4°K. In special cases, the company notes, a spool of one continuous length prepared from the same melt is provided and held for customers, with all thermocouples being fabricated from this spool. In such situations, interchangeability of better than 2 K is guaranteed.

Direct Reading Instruments with internal reference junction compensation for use with these thermocouples are also available, in a choice of indicating, recording or controlling functions.

With a sizable amount of our business due to saber-rattling on a national scale, it's heartening to discover some relay prospects among those who practice skewering each other just for fun. One of our reps recently wrote in, calling our attention to a device in which a buzzer sounds when a proper forward-moving fencing "hit" is scored. The buzzer circuit is closed by the contacts of a Sigma "22" relay, which in turn is wired to a battery and a plunger switch at the tip of the foil or épée. The inventor's name is L. A. Wortman, and he holds no lesser rank than chairman of the Electrical Weapons Committee of the Amateur Fencers League of America, as well as American Delegate to the Electrical Signaling Comm., Federation International D'Escrime.

We sincerely hope, however, that Mr. Wortman shows more mercy in a *salle d' armes* than he does to the hermetically sealed enclosure of his Sigma sensitive relay. In describing his ingenious boon to practice fencers (fencing practicers?), he calmly states "The relay is a Sigma Type 22J200 or equivalent... (These dual series) coils must be separated and reconnected ...The case of the relay is easily removed with a pair of diagonal wire cutters. Starting at the bottom edge and peeling, the cover comes off as though it were a sardine-can cover." *Really*, Mr. Wortman. If Series 22 relay enclosures were meant to be removable, we would have made them that way. (On second thought, maybe supplying a little key with each hermetically sealed Sigma relay might not be such a bad idea at that. Remember that Air Force captain and his little drill?)

At all events, this clearly points out one fact: clever people are still successfully applying Sigma relays in ways which turn our application engineers green (92 parts horror, 8 parts envy). We can only hope that future builders of electrical fencing instruments and kindred souls will first ask us if we have what they want, before picking up the side-cutting pliers. It might pleasantly surprise some to see the assortment of open and sealed, single- or dual-coil, magnetic latching, big and little relays we can offer. We might even have one for Mr. Wortman's august body which would signal a hit not by a buzz on a buzzer, but simply by saying "ouch."

"22" Bulletin on request; application engineering by letter and over the phone.

SIGMA

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CIRCLE 85 ON READER SERVICE CARD

Foam Pattern Simplifies Prototype Casting

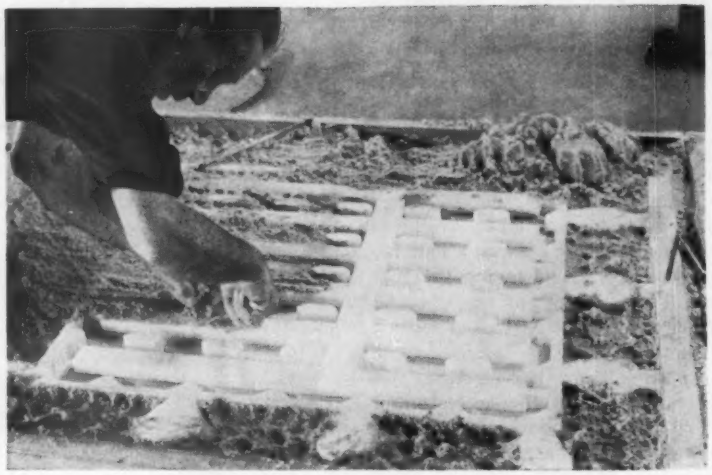
By RAYMOND A. HAGSTROM,
Metallurgist, Equipment Division,
Raytheon Company, Maynard, Mass.

FOAM VAPORIZATION CASTING can provide a solution to one of the most difficult problems in electronic packaging: obtaining engineering models of cast components in the shortest possible time. The technique is also advantageous for short-run production. It very nearly approaches the ideal solution of manufacturing a part without tooling.

In foam vaporization casting[1], the pattern is made from polystyrene foam. The material is easily worked and can be glued to make complicated shapes. The principal difference between this method and other forms of casting (described below) is that the pattern is not removed from the mold.

When the polystyrene foam pattern has been rammed into the sand and the gates and risers are cut, the metal is poured directly on the pattern. The foam vaporizes when it is contacted by the molten metal and the metal fills the mold cavity that is created by the vaporization.

The first photograph shows a polystyrene foam pattern in a flask before the cope is put in position. The average foundryman might think that excessive gas would be generated by this process. However, that is not the case. The metal is no more subjected to gas than any other method of molding. No unusual gas evolution is observed when the metal is poured into the mold.



Polystyrene model in position before mold is closed

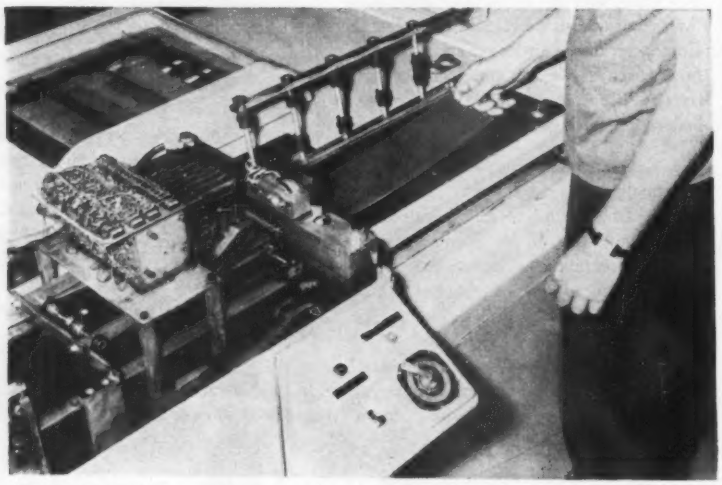
Photomicrograph of foam vaporization casting

The photomicrograph (unetched, 250X) shows the structure and freedom from entrapped gas in a foam casting. The material is 356 aluminum alloy.

Castings of practically unlimited complexity can be made by this method. No consideration need be given to removing the pattern from the sand or mold. The method seems to be suitable for any type of metal that can be poured by conventional foundry techniques.

Raytheon has made castings of electronic packages and crank

Programmed P-C Punching Machine



Tape-controlled punching machine handles printed circuit boards up to 6 × 18¼ inches. Holes are punched on 1/10-inch coordinates according to pattern punched on tape 12 inches wide and 36 inches long with 1/5-inch coordinates. Pattern is picked up by a vacuum reader bar, actuating a punch head with 59 free-floating punches. Indexing rate is 180 a minute. The machine was announced by Radio Corporation of America's Industrial and Automation Division, Detroit, Mich.

Riddle:

What has all the gold or silver it needs but doesn't have a nickel to its name?

GIVE UP? The answer is General Electric's gold or silver-plated tungsten or molybdenum wire.

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General Electric puts only one piece of wire on a spool—a long, long, long piece. Elongation ratings are exceptionally good. There's no delayed yield point on the stress-strain curve. You can choose either a high luster or dull finish, get experienced engineering help, and count on fast delivery.

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Check as many as you wish.

- ☐ Send me samples for testing.
- ☐ I'd like more specific information.
- ☐ I'd like engineering assistance.

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+5 UV ABSOLUTE
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PRECISION VOLTMETER

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range: 0 to 1000 volts D.C.

stability: ± .005% from 100 to 130 V.A.C.

temp. stability: 3 PPM/°C.

Model DC-100A: similar to DC-110A except for ± .05% accuracy and ± 5 PPM/°C. temperature stability... Price: 475.°

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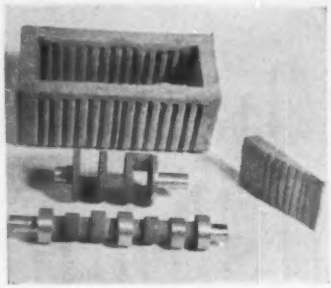
shafts by this method. The last photo shows a foam model and the casting made. The time from drawing to casting was less than three days. These castings were poured in the Massachusetts Institute of Technology foundry, under the direction of Professors Howard F. Taylor and Merton C. Flemings.

The rough surface of the castings is due to the surface condition of the polystyrene foam. A better surface condition could be obtained by smoothing the surface.

Foam vaporization casting is also adaptable to production castings which would be impractical or too expensive to cast by other means. Short-run production is particularly advantageous for the same reasons as prototype work.



Castings of an electronic package and crankshafts

In larger runs, there would be some instances where the simpler tooling would show a cost advantage over conventional casting methods. However, more care must be taken in feeding the metal in a production part. The crankshaft shown has three shrinkage areas. This is of little consequence in an engineering model, but could be disastrous in a production part. In production quantities, the polystyrene patterns could be made with a fixed gating system attached.

In normal sand casting, the casting pattern must be constructed so that it can be withdrawn from the sand without disturbing the impression. Complicated patterns require considerable core work to remove the pattern from the sand. If the design is modified after initial castings, a pattern change is required. These add up to an expensive pattern and much waiting time.

In investment casting, the wax or plastic pattern is melted from the mold before the metal is poured. However, extensive tooling is re-

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The Model DC-200AR is the most precise differential voltmeter to be found—unmatched in reliability, unbeatable in price. It is compact and lightweight... uses transistors and zener diodes exclusively... is *self-calibrating*... and warms up completely in less than 30 minutes. Here are a few typical specifications to check against your requirements:

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Foam model and its casting

quired to make the patterns and the size and weight of investment castings is limited. Recently, the use of ceramic materials rather than plaster has expanded the scope of this process.

Welded models have been used to save time. Welding is satisfactory if sufficient time is allowed for proper design of welding fixtures. Since this is generally impossible, the parts are welded without fixtures, resulting in a part that is either unsatisfactory or very expensive.

REFERENCE

(1) H. F. Shroyer, Cavityless Casting Mold and Method for Making Same, U. S. Patent No. 2,830,343, April 15, 1958.

Large Diamond Wheel Grinds Sapphire Rod

DIAMOND-COATED grinding wheel, 17 inches in diameter, is being used by Duncan-Inglewood, Inc., Inglewood, Calif., to grind small sapphire and quartz rods. The wheel (Dia-Chrome) is steel with small natural diamond grit bonded to its face. Mounted on a centerless grinder, it revolves at 3,000 sfm and is cooled with a heavy flow of water and oil emulsion. The firm reports that rods as fine as 0.025 inches with tolerances of 0.002 inch for diameter and concentricity can be ground on a production basis.

For Community TV Antenna Systems

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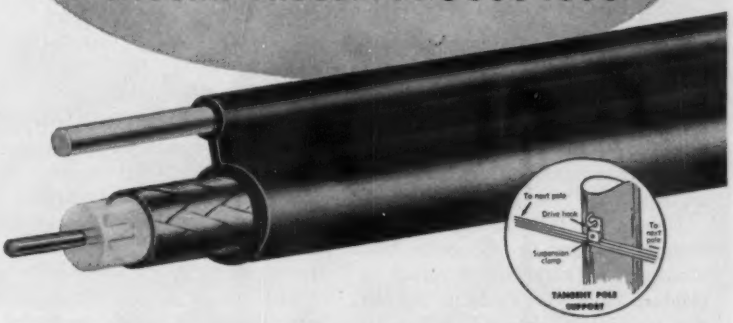
I. M. Cables

Install faster... Cost less



Because Hickory Brand Community TV Antenna System Cables need no separate messenger, installation time is reduced to a minimum.

These cables are especially constructed to keep cross talk and external interference to a minimum and to provide maximum attenuation to radiated signals. Conductor insulation and dielectric material is polyethylene.

	Dia. of Dielectric Ins.	Nom. Imp. Ohms	Attenuation DB/100 ft. 400 Mc	3000	Shielding Braid	Nom. Overall Dia.
RG-11/U	.285"	75	5.2	18.5	Single Copper	.405"
RG-59/U	.146"	75	9	30	Single Copper	.242"

Integrated Messenger is high-strength galvanized solid steel wire.

For community TV Antenna Systems, use quality-engineered and precision-manufactured Hickory Brand I. M. Cables and save time and money.

Write for complete information on the full line of

HICKORY BRAND Electronic Wires and Cables

Manufactured by

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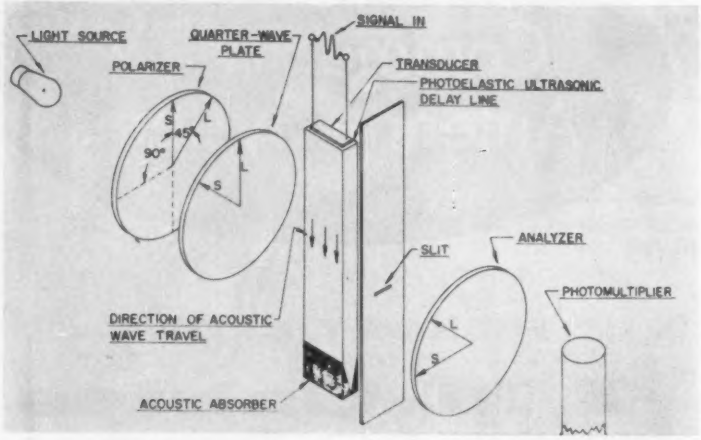
New On The Market



Ultrasonic Delay Lines

USE PHOTOELASTIC PRINCIPLE

CONTINUOUSLY variable time delay is obtained with photoelastic ultrasonic delay lines. Capabilities of the device include multiple tapping without loss of signal, and addition and multiplication of two or more signals.

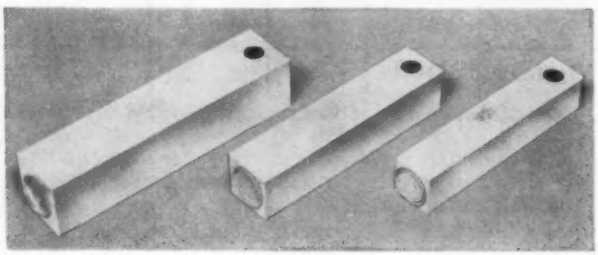
Delays to 160 microseconds at frequencies to 30 Mc have been obtained, with the input signal reproduced cycle-for-cycle at the output multiplier phototube. The devices are called photoelastic because an acoustic signal in a solid transparent delay line is detected optically.

Photoelasticity itself refers to certain changes in the optical properties of isotropic, transparent dielectrics when subjected to stresses.

In the delay lines, an acoustic signal induces stress in ultra-pure fused silica, and an allied optical system detects the resulting changes. Continuously variable delay is possible because the output can be tapped at any point along the medium.

The optical system consists of a light source, polarizer, birefringent phase delay plate, viewing slit, analyzer and photomultiplier. The delay lines will be manufactured by the Corning Electronic Components, Bradford, Pa.

CIRCLE 301 ON READER SERVICE CARD



R-F Filters

FOR SCREEN ROOMS

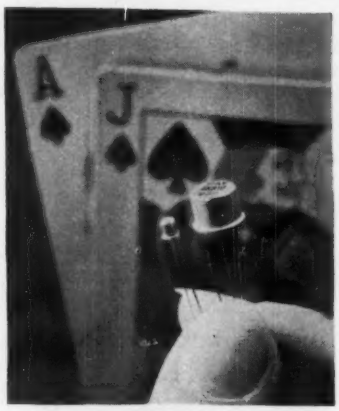
SCREEN room r-f filters have an insertion loss of more than 100 db over the frequency range from 100 Kc to 1 Gc and better than 40 db at 40 Gc. Since the insertion loss of the filters is at least as good as that of the screen rooms, maximum use can be made of rooms without interference from extraneous sources of RFI.

The filters are hermetically sealed in corrosion-resistant cases and have been designed to operate continuously at an ambient temperature of 40 C at full rated current. They have been engineered for dependability and long life as well as minimum size and weight. Each filter is individually tested for compliance with electrical specifications and for security of the hermetic seal.

Three standard filters cover the majority of applications and are rated at 30 amperes, 50 amperes, and 100 amperes, 250 v a-c/600 v d-c. Filters need not be derated for operation on a-c power lines over the frequency range of 0 to 400 cps.

Manufacturer is Sprague Electric Co., North Adams, Mass.

CIRCLE 302 ON READER SERVICE CARD



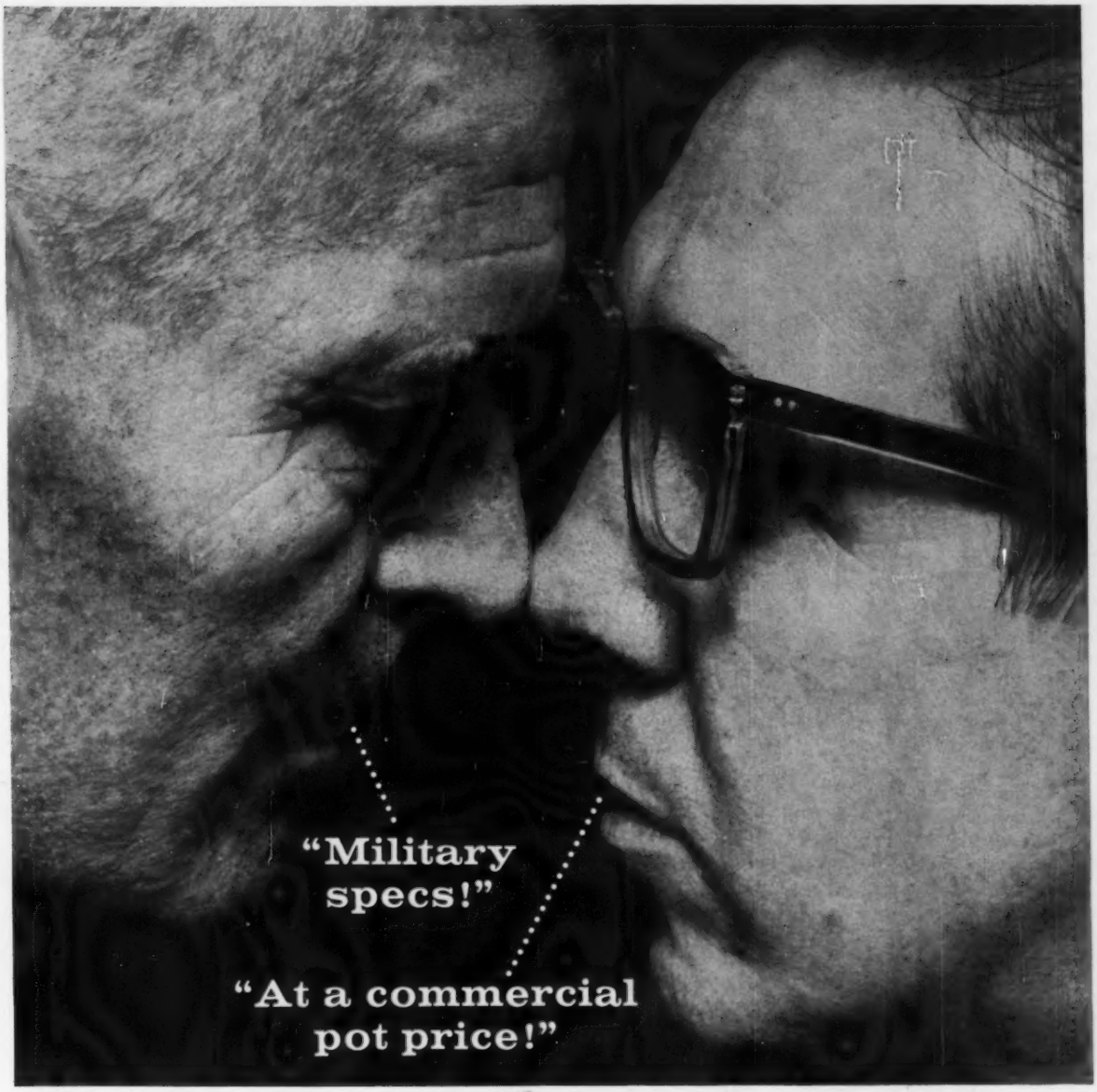
Small Transistors

WELDED GERMANIUM ALLOY

GERMANIUM subminiature transistors, 21 times smaller than presently available transistors with the same electrical characteristics, have been introduced by Raytheon Co., Semiconductor Division, 200 First Ave., Needham, Mass.

Electrical equivalents of *pnp* types 2N404, 2N428, 2N416, 2N417, and *npn* types 2N388 and 2N440, the subminiatures, all now in TO-5 packages, are respectively, 2N799, 2N805, 2N811, 2N813, 2N815, and 2N821.

Differing only in size, weight and dissipation, the six subminiatures are the smallest welded germanium alloy transistors available. They are hermetically sealed in a metal case with a metal and glass base and have maximum outside dimensions of 0.130 inch by 0.130 inch. The



Waters new sealed PT¾ potentiometer

Dust! Corrosion! Moisture! Vapors! All are foes of potentiometer reliability, yet ordinarily costly to keep out. Now, however, Waters introduces a new ¾" plastic case pot, the PT¾, meeting military sealed pot specs (MIL-R-19A, MIL-R-19/1A), yet priced no higher than many commercial grade pots! "O" ring shaft seal and complete internal sealing virtually eliminate environmental problems. Provides the same protection as encapsulation in less space. Resistance element is a copper mandrel wound with wire alloy which has a temperature coefficient of 20 P.P.M. per degree C. Resistance range 1 to 20,000 ohms. Dissipates 1.5 watts at 40°C. Available with split or plain bushings. Write for Bulletin PT 760.

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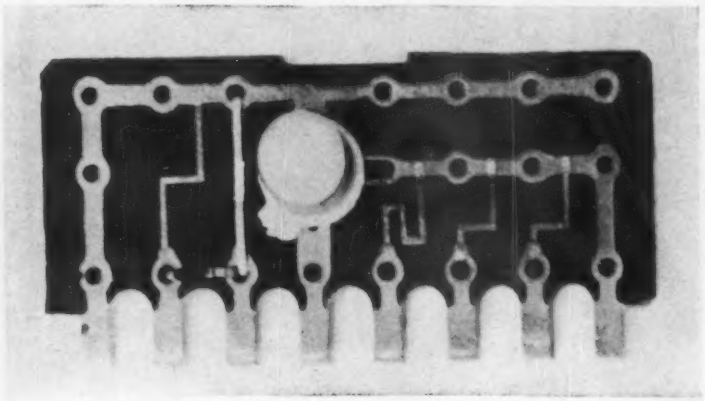
miniature germanium transistors are particularly suitable for use in radar systems, missiles, computers, communication, telemetry, and data transmission systems.

Collector dissipation of the new units is 70 mw at 25 degrees C. Available in quantity from distributors, the units are priced from $1.90 to $5.50 in 100 to 999 lots, within the continental United States.

CIRCLE 303 ON READER SERVICE CARD



Microcircuit Deck

A BUILDING BLOCK

A MICROCIRCUIT building block in the form of a universal logic deck is now available from CBS Electronics, Danvers, Mass. The deck performs an inverter/amplifier function and two of the decks can be connected to form a flip-flop.

Designed as a universal logic module, the basic microdeck can be used for a variety of logic functions. Special interconnection panels make possible multideck arrays from which individual decks can be readily removed and replaced.

The design approach to microcircuitry results in practical building blocks that can be incorporated into present equipment, giving increased component density compatible with present components. Encapsulation of the units also is practical.

The decks can be supplied with vacuum deposited thin-film resistors in place of discrete resistors; similarly, thin-film capacitors and semiconductors in either subminiature or unencapsulated form can be used.

The approach makes possible a rational, evolutionary transition from the proven components of today to the circuits of tomorrow. Specifications and nominal prices for the sample units are immediately available on request.

CIRCLE 304 ON READER SERVICE CARD

Permanent Magnets

DISTRIBUTED IN FLEXIBLE TAPE

FINELY divided magnetized particles are uniformly distributed in a flexible vinyl tape, with the result that one side of the tape has strong magnetic attraction over its surface while the other side is practically nonmagnetic.

The nonmagnetic side can be molded, embossed, hot-stamped, printed, silk screened or laminated with printed or unprinted foils, films or papers, and may be cut with a scissors or die-cut in mass production. For many applications, conventional magnets cannot be used because of cost. With the new tape, called Magnyl, cost is lower and its ease of handling allows unusual uses.

The tape will be furnished in standard bulk rolls, in widths from $\frac{1}{8}$ to 2 inches and from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick. Special widths, thickness and colors will be available to order; the material can also be extruded to order.

Uses already developed include production control boards, assignment boards, gaskets, and masking material for production finishing. It can stand the heat of baking ovens and is reusable. The tape is manufactured by Applied Magnetics Corp., 178 River Road, Leeds, Mass.

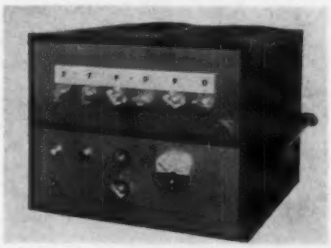
CIRCLE 305 ON READER SERVICE CARD

Voltage Reference

MEETS MIL SPECS

A-C VOLTAGE reference standard has been designed to military specs, is useful for standards laboratories and for testing instruments and components such as gyros and resolvers. The transistorized unit operates from 0 to 52 degrees C and to 20 g shock, making it suitable for field use and missile checkout stations.

Specifications include: range from 0 to 511.110 volts a-c rms;



accuracy of 0.035 percent of reading, ± 1 millivolt at 25 C; resolution of 1 millivolt over 6 decades; output frequencies of 45-55, 54-66, 36-440, 900-1,100 cps in steps, with frequency accuracy of 0.5 percent; power output of 10 va from 10 to 511 volts and 1 ampere from 1 to 10 volts. Price is $4,975 and delivery is from stock or within 10 weeks.

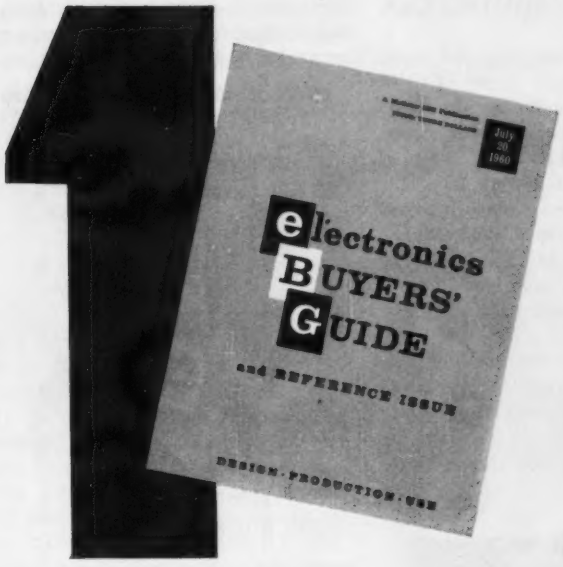
The standard is manufactured by Roteck Instrument Corp., 733 Concord Ave., Cambridge, Mass.

CIRCLE 306 ON READER SERVICE CARD

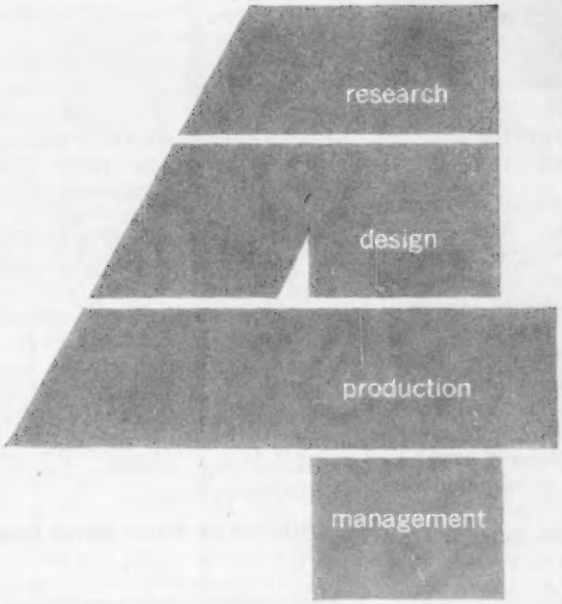
Silicon Diodes

FAST RECOVERY

A NEW LINE of silicon micro mesa diodes with reverse recovery as fast as 2 nanoseconds, and with 2 picofarad capacitance, is announced by Pacific Semiconductors, Inc., 10451



FIRST CHOICE OF ALL 4!



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S. C. E. TECHNICAL BULLETIN 2
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● **Celco YOKES**
keep spots **roundest**

● **Celco YOKES**
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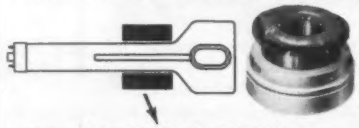

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Constantine Engineering Laboratories Co.

Main Plant: MAHWAH, N. J. DAvis 7-1123
• Pacific Division - Cucamonga, Calif. - YUkon 2-2688

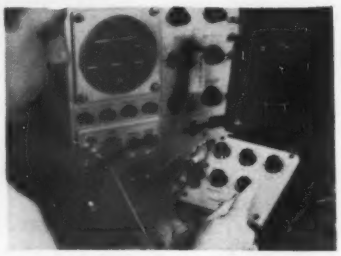
West Jefferson, Culver City, California.

Eleven types including electrical equivalents of EIA types 1N904 through 1N916 make up the line. Reliability is equal to or greater than conventional diodes.

In quantities of 100 to 999, the Micro Mesas diodes range in price from $2.50 for the 1N905 equivalent to $6.02 for the 1N916 equivalent. Delivery of production quantities is being made on all Micro-Diode types.

Complete details, curves, characteristics and ratings are contained in a new brochure available from PSI.

CIRCLE 307 ON READER SERVICE CARD



Function Generator
PORTABLE, VERSATILE

AIRBORNE INSTRUMENTS LABORATORY, Deer Park, Long Island, N. Y., announces an all-transistor function generator, type 120. Designed as a breadboard testing or trouble-shooting instrument, this unit provides sine-wave, square-wave or pulsed output. Package size is 6¼ by 6½ by 3¼ in., and weight is only 3 lb. The circuit features a Wien bridge oscillator followed by an agc amplifier to maintain constant output.

Output frequency range is from 30 cps to 39 Kc in six ranges. Sine-wave output is 0.8 v rms; square wave and pulsed outputs are 3 v peak-to-peak. Output amplitude is within ±1 db over the entire range. Pulse width can be varied from 2 to 10 μsec. Rise and fall time is 1 μsec. Total harmonic distortion of the sine-wave output is less than 3 percent. Minimum load impedance is 1,000 ohms for rated output; output impedance is less than 100 ohms.

The frequency dial is accurate to within 10 percent. Applications include measurements of audio amplifier gain and frequency response, filter response, and time constants, and triggering of pulse-forming networks. Price of the unit is $299.

CIRCLE 308 ON READER SERVICE CARD

Coax Attenuators
PRECISION UNITS

MODEL AS-1 precision attenuator set consists of 8 precision coaxial attenuators in a solid walnut, velvet-lined case with a stainless-steel nameplate. It is made by Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Attenuators included are Weinschel Model 210 (with a frequency range from 1 to 12.4 Gc) in values of 3, 6, 10 and 20 db, and Weinschel Model 50 (frequency range from d-c to 1 Gc) in values of 3, 6, 10 and 20 db.

All eight attenuators have stainless steel bodies and connectors (Type N, male/female) and are made with film resistors for maximum stability.

Mounted in the lid of each case is a plastic-laminated certificate of calibration giving data on each individual attenuator, including d-c resistance and insertion loss at selected frequencies.

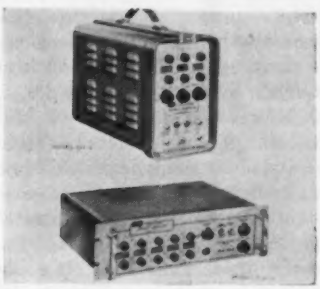
CIRCLE 309 ON READER SERVICE CARD

Crystal Oscillator
VOLTAGE CONTROLLED

HERMES ELECTRONICS CO., 75 Cambridge Parkway, Cambridge 42,

Mass., announces model 10M-VX all solid state voltage controlled crystal oscillator. Applications include use in narrow band telemetry, frequency tracking loops, and f-m modulation techniques to eliminate multiple conversions in transmitters. Center frequency range is 10 Kc to 30 Mc; deviation percentage, up to ±0.2 percent nominal. Wider ranges can be accommodated by using the unit in conjunction with a mixer. A maximum range of 0 to 50 Kc is easily attainable. Input voltage is ±5 v d-c; modulation rate, 0 to 0.6 percent of center frequency; input impedance, greater than 100 K ohms; linearity, ±1 percent of maximum deviation for narrow band oscillators; ±2 percent of maximum deviation for wide band oscillators. Output power is 1 to 10 mw into a 100 ohm load; power supply voltages, ±20 v typical.

CIRCLE 310 ON READER SERVICE CARD



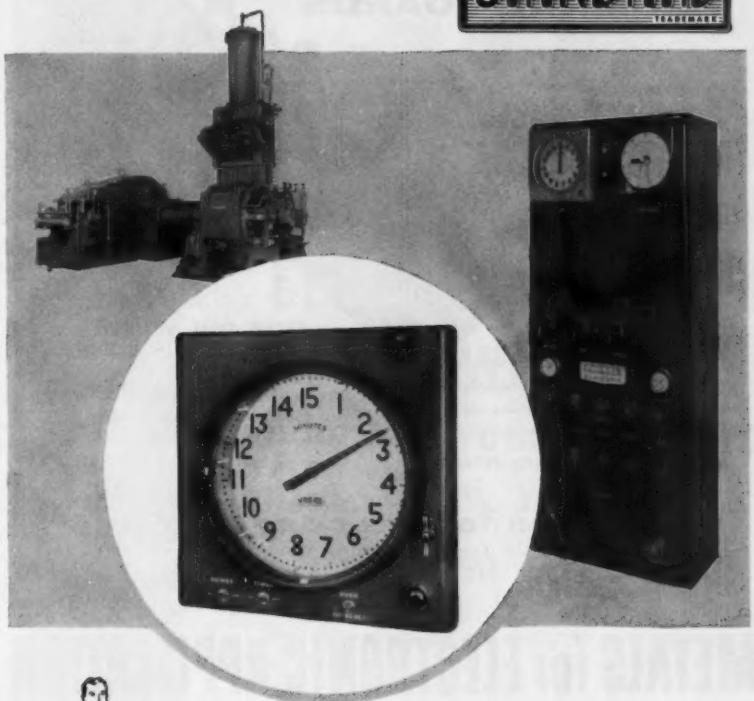
Marker Generators
CRYSTAL CONTROLLED

JERROLD ELECTRONICS CORP., 15th and Lehigh Ave., Philadelphia 32, Pa., has developed two new crystal controlled marker generators, models CM-6 and CM-10, which, though they contain six and ten crystal oscillators respectively, use harmonic and side band techniques to attain many more marking indications. Utilizing a single center frequency oscillator, it is possible to choose two side band oscillator frequencies to provide a total of five marks, one at the center frequency, two at the band edges and two at the 3 db down points. The CM-6 is housed in a portable cabinet and the CM-10 is for rack mounting. Both provide frequency references on response curves of filters, amplifiers and other equipment requiring a predetermined frequency specification. The out-

Actuating Audible Signals . . .

Another of Countless Applications of

SPECIAL TIMERS by STANDARD



A specially developed Standard batch timer, with pins which can be positioned as desired, actuates audible signals to assure proper manual operation of critical equipment.

What's *your* need in special timers? Precise process timing—as on this Farrel-Birmingham Banbury® mixer? Or accurate test timing (to tolerances of ± .001 second)—as with numerous electronics and missile manufacturers?

Whatever the application, STANDARD stands ready to develop the exact elapsed time indicator to meet the most stringent requirements.

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Request Catalog No. 198A covering the full line of STANDARD Precision Timers . . . portable or panel mounted.

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AIRCRAFT TYPE TERMINAL BOARDS

New series of Molded Terminal Boards available in three basic types—AN, NAS and MS. Special compoundings, backing strips and hardware on request.

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Gen-Pro's expanded line enables you to order all types of Terminal Boards from a single source; standard military, commercial, and others for special applications.

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METALS for ELECTRONIC APPLICATION rolled ULTRA THIN

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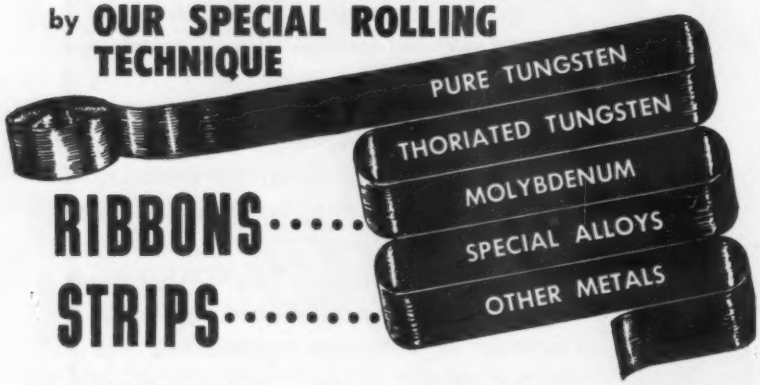

RIBBONS.....
STRIPS.....

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Note: for highly engineered applications—strips of TUNGSTEN and some other metals can be supplied *rolled down to .0003 thickness*

- Finish: Roll Finish—Black or Cleaned
- Ribbons may be supplied in Mg. weights if required

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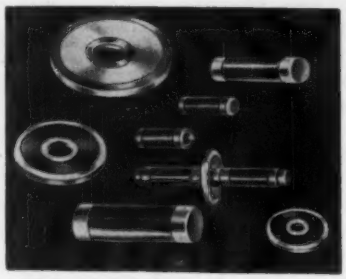
Tele: Union City, N. J. UN. 3-1134
N.Y.C., N.Y. BR 9-4425

put amplitude of each oscillator is individually controlled. The generators are also equipped to provide d-c marker indications, necessary when using X-Y recorders.

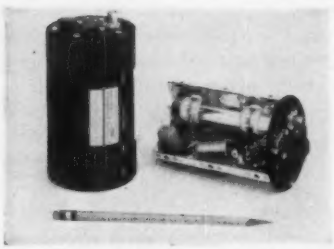
CIRCLE 316 ON READER SERVICE CARD



Carbon Resistors
THIN-FILM

FILM RESISTORS, INC., 242 Ridgedale Ave., Morristown, N. J., is producing a new line of thin-film carbon resistors. They are specially designed for use in microwave attenuators, precision coaxial terminations, dummy loads, coupling loops and other special applications. The components offer excellent high frequency characteristics (d-c to 10,000 Mc, useable to 100,000 Mc) and stability plus superior performance under pulse applications. Pyrolitically deposited films on selected substrates are completely protected with special epoxy resins. Extremely thin films and lack of spiralling, result in minimum inductances. Company provides tight tolerances (±1 percent standard), high reliability and economy in standard or special disk and rod types.

CIRCLE 317 ON READER SERVICE CARD



Transmitter
L-BAND TYPE

R S ELECTRONICS CORP., 435 Portage Ave., Palo Alto, Calif. Packaged for either airborne or ground use, a typical application of the model 2701 L-band transmitter would be

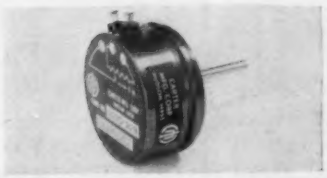
for a beacon on target missiles. Specifications include a frequency range of 1,650 to 1,680 Mc, f-m modulated with a minimum power output of 800 mw. The transmitter contains an integral power supply and operates from an input power of 0.7 amp at 29 v over a temperature range of −55 to 72 C. Size, 5½ in. long by 3⅞ diameter.

CIRCLE 318 ON READER SERVICE CARD

Portable Tester
PHASE SEQUENCE

SPACE ELECTRONIC LABORATORIES, P.O. Box 447, Lynbrook, N.Y., announces a phase sequence tester for 3-phase servo motors, generators and power supplies. It is completely self contained for laboratory bench or field use. Tester determines phase rotation by connecting it to the three lines of the 3-phase circuit under test and corresponding lamp lights—either ABC or ACB. No neutral connection required. Specify desired frequency—50, 60, 400 or 1,000 cps etc. and line voltage —28, 115, 220 etc. Delivery from stock or to custom requirements. Price: $15.95.

CIRCLE 319 ON READER SERVICE CARD



Precision Pots
HIGH RELIABILITY

CARTER MFG. CORP., 23 Washington St., Hudson, Mass., announced a line of 1⅛ in. diameter precision pots. Developed especially for high reliability applications, these units continue to meet their original specifications after 2,000 hours of operation at 150 C. Standard resistance values range from 100 ohms through 50,000 ohms. All values, even the 100 ohm units, may be obtained with conformities of 0.14

WHAT 15 DEPENDABLE
SLIDE SWITCHES
CAN DO FOR YOUR PRODUCTS

ADD COLOR—Trigger knobs in 10 attractive colors add decorative and functional touches to switching operations.

CUT COSTS—Low in initial cost, Stackpole Slide Switches often reduce costs up to 50% over other type switches.

SAVE SPACE—Stackpole Slide Switches take less panel area, often less depth than conventional switches.

SIMPLIFY PRODUCTION—Choice of solder lug or printed wiring terminals, clearance or tapped-extrusion mounting holes.

HANDLE HIGHER LOADS—0.5- to 1-amp types for electronic equipment. 1-, 3-, and 6-amp types for appliances and power tools.

SWITCH COMPLEX CIRCUITS—1- to 3-poles, 2- to 4-positions for real switching versatility.

FACILITATE OPERATION — Trend-setting slide action available with or without detents and spring returns. Plunger-operated and matching pushbutton styles also available.

Write for Slide Switch Bulletin

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ELECTRONIC COMPONENTS DIVISION
STACKPOLE CARBON COMPANY, St. Marys, Pennsylvania

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TRANSISTOR CIRCUIT DESIGN

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Non-Magnetic

18-8 TYPE 303 STAINLESS

UNIVERSAL JOINTS

Manufacturers of electronic equipment have come to depend on Curtis for precision-made non-magnetic universal joints of 18-8 Type 303 stainless steel, in the sizes most frequently used in the industry. Other sizes are also readily available; also bronze joints.

Curtis joints benefit by a rigid insistence on uncompromising inspection and quality control at every stage of manufacture, insuring minimum backlash.

Curtis torque and load ratings are entirely dependable, since they are based on continuous testing under actual operating conditions.

Not sold through distributors. It will be to your advantage to write or phone (REpublic 7-0281) for free engineering data and price list.

CURTIS TRADE MARK

UNIVERSAL JOINT CO., INC.
1911 Birnie Avenue, Springfield, Mass.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

CIRCLE 204 ON READER SERVICE CARD

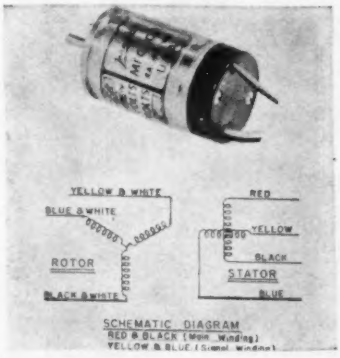
percent if required. Terminals are guaranteed against any type of damage except the breaking off of turrets (this requires approximately 45 in. oz torque). Price: $50 or less, depending on quantities and modifications required.

CIRCLE 320 ON READER SERVICE CARD

D-C Power Supply
HIGHLY RELIABLE

AUTOMATION DEVELOPMENT CORP., Culver City, Calif. Model A201A is a very low cost unit designed to serve as a power supply for the company's new line of step-servo components. It will find wide application in manufacturing, field and laboratory applications. Unit measures 9 in. high, 6½ in. wide, and 9 in. deep, and weighs 13½ lb. Output voltage is 28 v, d-c, nominal (non-regulated); output current, 2 amperes, maximum; output ripple, 3 v, peak, maximum; input, 115 v, 60 cps, 100 w single phase a-c.

CIRCLE 321 ON READER SERVICE CARD

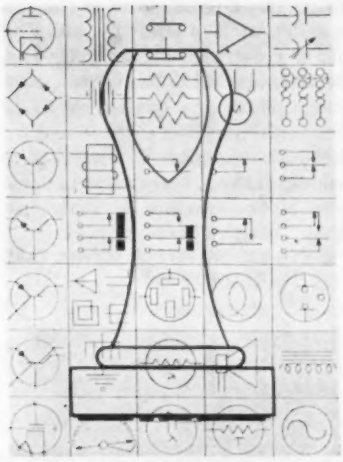


Transolver
ROTOR FED

JOHN OSTER MFG. CO., Avionic Division, Racine, Wisconsin. Type 4255-01 transolver synchro is unusual in that the rotor is used as

primary instead of the stator. Exceptional compactness is attained by including in the size 8 housing, high impedance and dual output winding which may be used in signal circuits. Error variation is ±7 minutes checked as a control transformer with rotor excited using main stator winding red and black. Input voltage is 11.8 using rotor as primary, input current 0.036 ampere, input 0.108 w, output 22.5 v, lead phase shift 12.3 deg, rotor resistance 86 ohms, stator resistance 310 ohms, Z_{RO} = 88 + J275 ohms, Z_{SO} = 437 + J1580 ohms, Z_{RSS} = 113 + J29.5 ohms, null voltage 30 mv, temperature range −55 C to +125 C and net weight 1.6 oz. Stainless steel is used for supercritical parts such as housing, shaft and bearings.

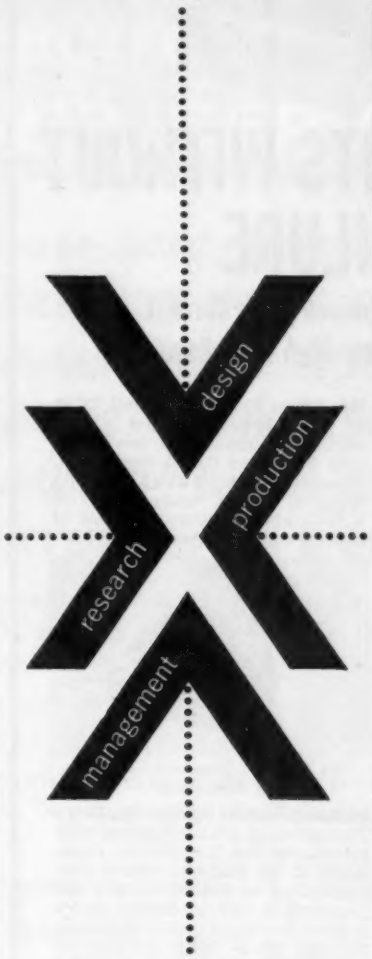
CIRCLE 322 ON READER SERVICE CARD



Rubber Symbol Stamps

AID ENGINEERS

PAPER EQUIPMENT DISTRIBUTING CO., P. O. Box 90, Prince St. Station, New York 12, N. Y. Utilizing the standards established by the American Society of Electrical Engineers, American Standards Association, Military Standard Electrical and Electronic Symbols and the U. S. Bureau of Standards, the company has created a complete line of symbols reproduced on rubber stamps. Very low in cost, either in sets or individually, these technical stamps eliminate tedious detail work, inaccuracy of rough sketching, and can be used either for layout and design work or as finished drawing to be reproduced



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  K16 SHRIKE
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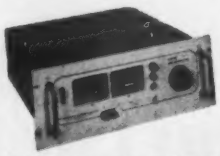
Power Supplies



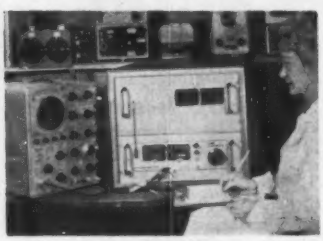
7000 SHORT CIRCUITS WITHOUT A SINGLE FAILURE

Wide Range Transistorized High Current Power Supplies Set New High In Reliability

Con Avionics proves extreme reliability of its zero to 50V rack mounted power supplies with a graphic demonstration at the 1960 I.R.E. Show.

Throughout the Show a new model Z50-15 Power Supply was short-circuited every 30 seconds, yielding a total of 7,000 short circuits without a single failure. Several thousands more shorts were applied during laboratory tests.

The company's new line of power supplies was designed under a "worst case analysis" program. The supplies are designed using standard non-selected components; performance is then mathematically and experimentally checked with the worst possible combination of component characteristics. This design technique is largely responsible for the new high set in reliability and insures long life and easy field maintenance.



"Worst Case Analysis" Program Helps Set New High In Reliability

Wide Voltage Range, High Current Capacity, Among Electrical Features • The units are available in two series with 0.1% and 0.01% regulation. They have an unusually wide range of output voltage: 0 to 50 V.D.C., and an output current of 2, 5, 10 and 15 amperes.

"Flip Top Box" Permits Accessibility For Maintenance

Mechanical Features Highlight Flexibility • The new units are constructed with remote sensing to maintain regulation at the load and remote programming to permit output adjustment at remote control point. A floating output is also provided, through which either positive or negative terminals may be grounded. All the power supply units have a voltmeter and an ammeter. The front panel has a power switch, circuit breaker, coarse and fine voltage adjustment knobs, input fuse, pilot light and output terminals. Rear panels have an input line cord, output, remote sensing, and programming terminals.

Specifications	Y Series	Z Series
Input Power	105 to 125 VAC, single phase, 48 to 62 cps.	
Output Voltage	0 to 50 VDC	
Output Current	2, 5, 10 and 15 amperes	
Regulation		
a) for line variations	± 0.1%	± 0.01%
b) for load variation no load to full load	0.1% or 5 mv (whichever is greater)	0.01% or 1 mv (whichever is greater)
Stability for 8 hours after 30 minute warm up	± 0.25%	± 0.05%
Ripple (rms)	2 mv	1 mv
Response time	50 microseconds	
Ambient temperature range	0°C to +50°C	
Temperature coefficient (% per °C)	0.02	0.01
Output Impedance at 10 KC (ohms)	0.003	0.0003

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EDgewood 4-8400

by a variety of copy methods. Complete information, catalog of designs and prices are available from the company.

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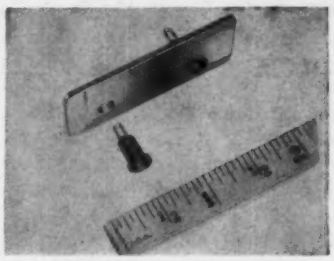

Test Jacks
NYLON INSULATORS

AUGAT BROS., INC., 33 Perry Ave., Attleboro, Mass., announces Push-Fit test jacks for use with 0.080 diameter probes. No external hardware is required to mount the component into a panel board or chassis. Installation is simply by pressing into a pre-drilled or punched hole. Contacts are beryllium copper, electro-tin plated of a quality equalling the requirements of the standard electronic circuit. Insulators are molded Nylon, and are available from stock in colors of blue, red, black. Other colors on request.

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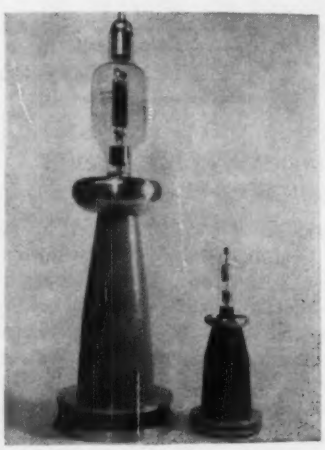

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COMPONENTS FOR RESEARCH, INC., 979 Commercial St., Palo Alto, Calif. Integrating the rectifier filament transformer into the solid epoxy resin body, the company provides a compact standoff bushing

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The Reprint Service Department offers 4 types of reprints: 1 — Reprints Reports as they appear with definite costs for varying quantities; 2 — Reprint Reports that have appeared in past issues; 3 — Reprints of other editorial ma current issues (minimum order is 100); and 4 — Reprints of editorial that, has past issues (minimum order is 100). On other than Special Reports we cannot p because the order may involve any number of editorial pages depending upon the article.

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377	380	383	386	389	392	395	398
378	381	384	387	390	393	396	399
379	382	385	388	391	394	397	400

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with rugged characteristics and low power losses. Three available types of filament transformers cover most of the commonly used rectifier types. Type CRF-150 K (illustrated, left, on p 100) provides a 150 Kv peak isolation in air or oil. The bushing is 22 in. high and 11 in. o-d. It contains a filament transformer with a primary designed for 100-to-135-v 60-cps power and a secondary, supplying from 20 v at 32 amperes to 5 v at 32 amperes. Type CRF-75K (illustrated, right) provides a 75 Kv peak isolation in air or oil in a unit 11 in. high by 7 in. o-d max. The filament transformer has the same primary arrangement but a secondary range from 5 v at 7 amperes to 2.5 v at 14 amperes.

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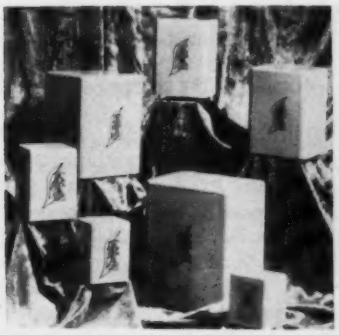

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ULTRA-ISOLATION TYPE

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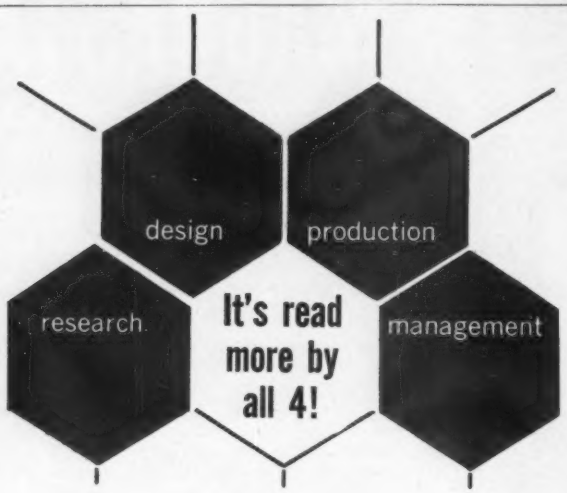

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Literature of

DOPPLER NAVIGATORS Laboratory For Electronics, Inc., 1079 Commonwealth Ave., Boston 15, Mass., has published a new technical data digest describing its capabilities in airborne doppler navigation systems. The eight-page, illustrated brochure details specifications of these equipments, including system philosophy, operational capabilities and performance, and various models of the doppler navigators produced.

CIRCLE 327 ON READER SERVICE CARD

TRANSISTOR TEST SET Baird-Atomic, Inc., 33 University Road, Cambridge 38, Mass. Design specifications for the direct reading, variable duty cycle power transistor test set, model NC-1, are given in a technical data sheet.

CIRCLE 328 ON READER SERVICE CARD

PRECISION POTENTIOMETERS Duncan Electronics, Inc., 1305 Wakeham Ave., Santa Ana, Calif. Three new technical bulletins, describing the series 1200, 1300 and 3200 potentiometers, are complete with mechanical, electrical, environmental, physical and general specifications and include descriptions of the design considerations of the units.

CIRCLE 329 ON READER SERVICE CARD

MICROWAVE TEST EQUIPMENT Waveline, Inc., Caldwell, N. J., has published a new four-page brochure illustrating and describing a complete line of microwave test equipment in the WR-51 waveguide size.

CIRCLE 330 ON READER SERVICE CARD

ELECTRONIC FILTERS Deltronics Inc., 100A Manton Ave., Providence 9, R. I. A recent brochure contains general specifications for a line of low pass, high pass and band pass filters as well as Select-A-Filter curves and explanation of their uses.

CIRCLE 331 ON READER SERVICE CARD

D-C POWER SUPPLIES General Electric Co., Schenectady 5, N. Y. Bulletin GED-4184, 8 pages, discusses a new standard line of

precision-regulated, transistorized d-c power supplies for a wide variety of applications in the utility, industrial, military and electronics area.

CIRCLE 332 ON READER SERVICE CARD

SPECTRUM ANALYZERS Raytheon Co., 1415 Providence Turnpike, Norwood 67, Mass. A new brochure describes the complete line of Rayspan spectrum analyzer models. It explains the Rayspan features which make possible complete spectrum analysis at rates as high as 200 times per sec with resolution maintained at 0.7 percent to three percent of the band for two equal-amplitude signals.

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SEMICONDUCTOR CATALOG Hoffman Electronics Corp., 1001 Arden Drive, El Monte, Calif. A 20-page three-hole punched catalog contains electrical and physical parameters of the company's silicon solar devices, silicon transistors, silicon diodes, silicon controlled rectifiers, Zener regulators and Zener reference devices.

CIRCLE 334 ON READER SERVICE CARD

DIGITAL VOLTMETER Non-Linear Systems, Inc., Del Mar, Calif., is offering a new two-color, six-page bulletin on the high accuracy V44 all-electronic digital voltmeter.

CIRCLE 335 ON READER SERVICE CARD

COMMUNICATIONS EQUIPMENT Westrex Corp., a division of Litton Industries, 540 W. 58th St., New York 19, N. Y. Details of the Westrex 11-type radio transmitting equipment are contained in a four-page illustrated brochure.

CIRCLE 336 ON READER SERVICE CARD

TIME PROGRAMMER Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Bulletin 3304-A-5 describes the MicroSADIC/time programmer. Specifications and a block diagram are included.

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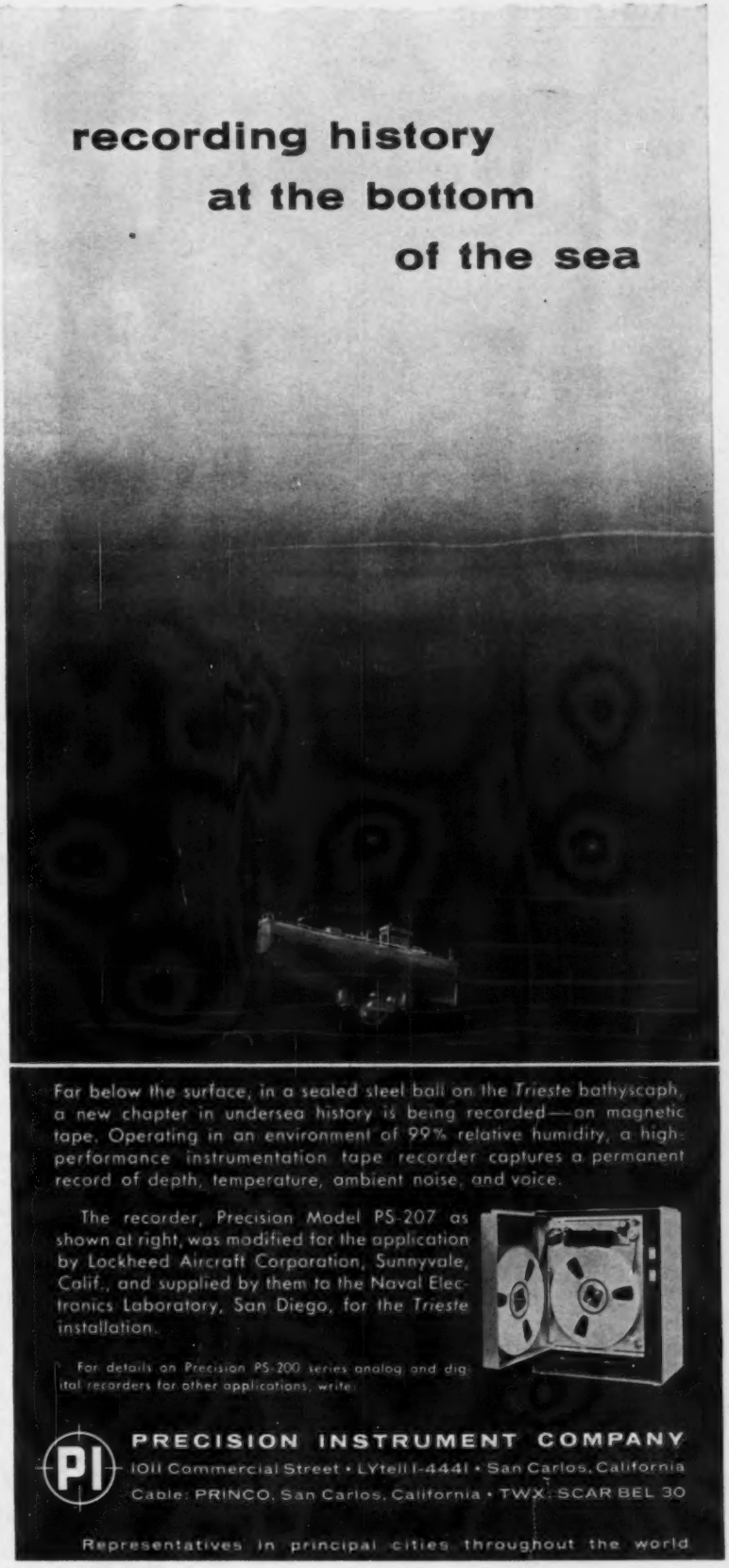
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The recorder, Precision Model PS-207 as shown at right, was modified for the application by Lockheed Aircraft Corporation, Sunnyvale, Calif., and supplied by them to the Naval Electronics Laboratory, San Diego, for the Trieste installation.
For details on Precision PS-200 series analog and digital recorders for other applications, write:
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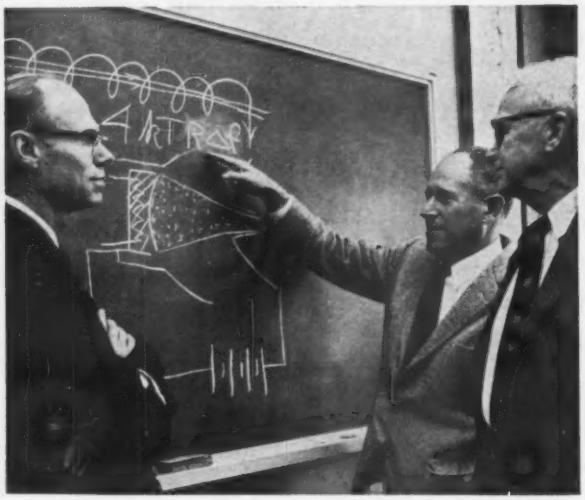

Franklin Institute Honors Electronics

FRANKLIN INSTITUTE's big Medal Day celebration, held recently at the Institute's headquarters in Philadelphia, was a quiet demonstration of the prominence of electronics in the scientific community.

Every Fall, the scientific society's Committee on Science and the Arts awards a score of medals to various outstanding contributors to progress. Despite the committee's designation, the awards usually stress the sciences, reflecting the primary interests of both the Institute and its founder.

Over the last decade, the incidence of electronics engineers and scientists has grown. This year, nine medalists received awards for electronic projects and six more for work directly related to electronics. Highest award—the 46-year-old Franklin Medal—went to chemical researcher Roger Adams of the University of Illinois.

All three Ballantine Medals, the Institute's second most distinguished award, went to engineers from Bell Telephone Laboratories. Rudolf Kompfner and John R. Pierce (at left and center in the picture) were honored for development of a traveling-wave tube amplifier. Harry Nyquist (at right in the photo) received a Ballantine Medal for work in communications systems engineering.

Two of the three Wetherill Medals went to electronics researchers. Raymond Castaing of the University of Paris solid-state physics lab received one for his electron probe microanalyzer, and geophysicist Victor Vacquier of Scripps Institute of Oceanography got the other for his airborne magnetometer. The third went to Walter Juda of Ionics Inc. for work in desalting sea water.

The Potts Medal was awarded to Charles S. Draper of MIT's instrumentation lab for work in the field of inertial navigation.

Of the four Longstreth Medals, three were won for electronic projects: by Veterans Administration medical researcher W. E. Chamberlain for radiological engineering; J. W. Coltman of Westinghouse for an X-ray image amplifier; and F. A. Keidel of Du Pont for an electrolytic moisture analyzer. The fourth went to M. B. Taylor of Aerocar for development of a flying automobile.

The three Cresson Medals, oldest of the Institute's awards, were awarded for work in related technologies. NASA deputy chief Hugh Dryden got one for his years of research in aerodynamics and guided missiles; Westinghouse researcher A. L. Nadai received another for work in elasticity and plastic flow of materials; and W. F. G. Swann, emeritus director of Franklin Institute's Bartol Research Foundation, was honored for cosmic-ray investigations.

The Certificate of Merit, established in 1882, was awarded to metallurgist R. R. Moore of Navy's Air Materiel Center for work in fatigue-testing of materials.

The two Levy Medals were awarded for work analyzing the human operator as a servo system element. One went to E. S. Krendel of Franklin Institute's own engineering psychology laboratory, and the other to Duane T. McRuer of Systems Technology Inc.

The five remaining awards were the two Henderson Medals, two Clark Medals and the Brown Medal. These were awarded respectively to Ernest Chatterton and Herbert Sammons for development of the "Deltic" diesel-electric locomotive for D. Napier & Sons, London; Robert W. Cook and Lee F. McBride of C. W. Fuelling Inc., for work in leak-sealing of gas mains; and R. B. Fuller, structural designer, for development of geodesic domes.

Raytheon Promotes Kenneth Hudson

PROMOTION of Kenneth Hudson to manager of the countermeasures department at Raytheon Company's Santa Barbara, Calif., operations is announced.

A section manager for the past two and one-half years, he joined Raytheon in 1957 as a staff engineer in the company's Maynard, Mass., research and development

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THUMBWHEEL SWITCHES

TABLET U.S. Patent 2,841,660

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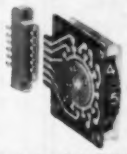
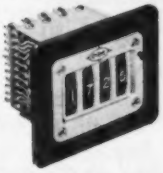
- **Available with internal lighting MIL-L-25467A.**

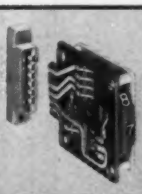
Permanent wafer type, Series TSD-P. Only ½" panel space needed per module. Also available in multi-deck series TM.



Removable wafer type, Series TSD-R. For continuous operation applications where interruptions must be held to an absolute minimum.



Permanent wafer type, Series TSB-P. Available in 8, 10, 12 or 16 positions, up to 36 switches per assembly.



Removable wafer type, Series TSB-R. For applications where maintenance time is valuable and rapid servicing a necessity.

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Phone: WEllington 5-4600

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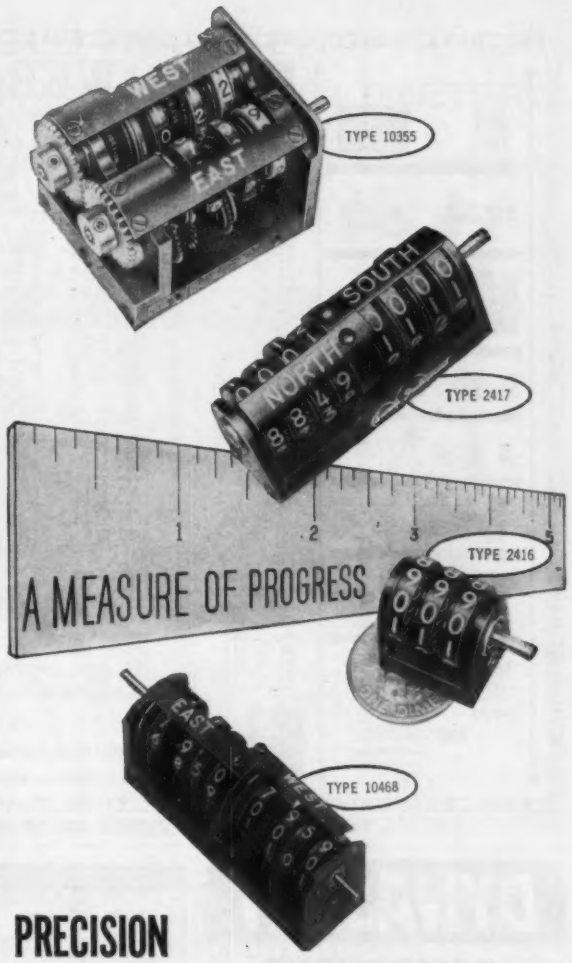

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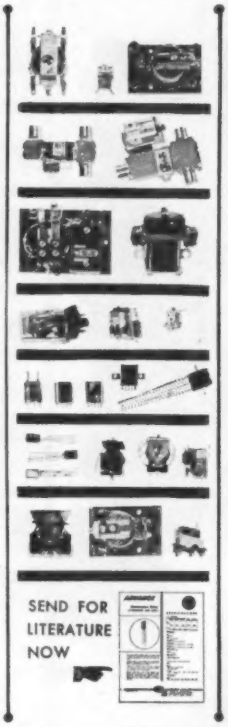

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POWER CONTROL TYPES

TYPE	CONTACTS*	COIL VOLTAGE (VAC)
PC/1C	SPDT 15A	6, 12, 24, 115, 220
PC/2C	DPDT 15A	6, 12, 24, 115, 220
PC/3C	3PDT 15A	6, 24, 115, 220
PC/4C	4PDT 15A	6, 24, 115, 220
		COIL VOLTAGE (VDC)
PC/1C	SPDT 15A	6, 12, 24, 110
PC/2C	DPDT 15A	6, 12, 24, 110
PC/3C	3PDT 15A	6, 12, 24, 110
PC/4C	4PDT 15A	6, 12, 24, 110

		COIL VOLTAGE	COIL RES. DC (OHMS)
PG/2C/6VA	DPDT 15A	6 VAC	1.4
PG/2C/24VA	DPDT 15A	24 VAC	25
PG/2C/115VA	DPDT 15A	115 VAC	400
PG/2C/220VA	DPDT 15A	220 VAC	1600
PG/2C/6VD	DPDT 15A	6 VDC	16
PG/2C/12VD	DPDT 15A	12 VDC	63
PG/2C/24VD	DPDT 15A	24 VDC	250
PG/1Z/6VD	SPDT 30A	6 VDC	16
PG/1Z/115VA	SPDT 30A	115 VAC	400

POWER TRANSFER TYPES

PH/1A/6VD	SPSTNO 20A	6 VDC	16
PH/1A/115VA	SPSTNO 20A	115 VAC	400
PH/1C/6VD	SPDT 20A	6 VDC	16
PH/1C/115VA	SPDT 20A	115 VAC	400
PV/1A/6VD	SPSTNO 30A	6 VDC	16
PV/1A/115VA	SPSTNO 30A	115 VAC	450
PV/1C/6VD	SPDT 30A	6 VDC	16
PV/1C/115VA	SPDT 30A	115 VAC	450

*Resistive rating

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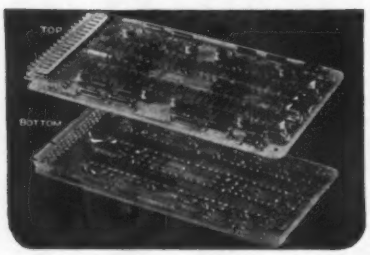
DYNASERT

COMPONENT INSERTING for More Uniform PW Boards



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laboratory.

Previously, Hudson served in engineering and managerial positions with the Allen B. DuMont Laboratories from 1955 to 1957, Sperry Gyroscope Co. from 1951 to 1955, and Emerson Electric Co. for one year.

CBS Electronics Names Niemann

APPOINTMENT of L. H. Niemann as director of government relations for CBS Electronics, Danvers, Mass., electronic manufacturing division of Columbia Broadcasting System, Inc., has been announced.

Niemann was previously semiconductor sales manager. His new headquarters will be in Washington, D. C.

Kidco, Inc., Appoints Chief Engineer

ED OSTENSACKEN was recently appointed chief engineer of Kidco, Inc., Medford, N. J., manufacturer of deposited carbon and metal film resistors. He was formerly project engineer at Clifton Precision Products Co., Clifton Heights, Pa.

Royco Instruments Moves to Palo Alto

ROYCO INSTRUMENTS, INC., has moved its offices and production facilities from Mountain View, Calif., to a 6,250-sq ft structure in Palo Alto. In addition to the engineering and production of the corporation's line of temperature-measuring instruments, the new facility will also house initial production on the recently introduced Royco atmospheric-particle monitor. Twenty-five engineering, produc-

tion, and office personnel are currently employed.

Arco Electronics Doubles Space

ARCO ELECTRONICS recently signed a long term lease on 46,000 sq ft of space at Lake Success Business and Professional Park in Lake Success, L. I., N. Y. The company will be doubling its space through this move.

At present there are no changes in location of its factory in Terryville, Conn., and the branch warehouse and offices in Dallas, Texas and Los Angeles, Calif.

Smith Electronics Hires Phillips

CHESTER C. PHILLIPS has joined the firm of Smith Electronics, Inc., Cleveland, O., as project engineer. He was formerly associated with Melpar in Falls Church, Va., as principal engineer.

In his present post, Phillips will be assigned to research and development work on high power steerable and multiplex antennas.

Kollsman Sets Up Research Division

KOLLSMAN INSTRUMENT CORP., Elmhurst, N. Y., has announced the formation of a research division and the appointment of Arthur S. Robinson as director of research.

The new organization will undertake basic and applied research related to advanced tracking, computing, communications, control, instrumentation and display systems.

Prior to joining Kollsman, Robinson directed the advanced elec-

SINGLE TRANSIENT PEAK READING VOLTMETERS

Model PRV-2 Single Transient Peak Reading Voltmeter. Approximate size, 10½" x 20" x 15¾". Weight, 55 pounds.

Read single transient pulses with 1% accuracy

The Curtiss-Wright Model PRV-2 Single Transient Peak Reading Voltmeter reads out the peak amplitude of rectangular pulses of 25 microseconds or greater rise time to an accuracy of 1%. Rate of fall required to initiate cycle is 0.2 volts per microsecond on the 1200-volt scale and 0.02 volts per microsecond on the 120-volt scale. Read-out is provided, directly in volts, as a 4-digit decimal value. The first peak voltage detected blocks further input values until reset.

You can use Model PRV-2 for peak pulse measurement wherever an oscilloscope would be too inconvenient—or too inaccurate. It is perfect for blast studies, shock studies, spherics measurements, to measure any transient phenomena which can be characterized by a voltage pulse. Input range: 3-120 volts @ 200 Kohm, 20 uuf input impedance; 30-1200 volts @ 2 megohm, 20 uuf input impedance. And, of course, the PRV-2 can be modified to accommodate a variety of input requirements.

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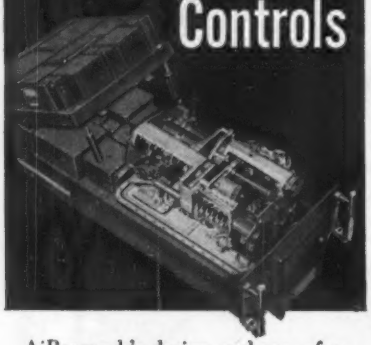
Automatic Sequencing Controls



AiResearch's design and manufacturing capability covers many types of automatic sequencing controls such as those for missile ground checkout, controlling drone and missile flight profiles, and automatic elevation and leveling of radar antennas and missiles.

Above is an AiResearch sequence controller for cabin temperature of a jet airliner. It assimilates 25 sensor element inputs and supplies command signals to 18 amplifier channels. Consisting of servo-operated potentiometer cards, cam switch programmer and other electromechanical components, it is another example of AiResearch's over-all ability to design and produce intricate and complicated servo systems.

The most experienced company in the development and production of control systems for airborne and ground use, AiResearch is an industry leader in electromechanical systems and components of all types for aircraft, ground handling, ordnance and missile systems.

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AiResearch Manufacturing Division

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Fit curved surfaces
Nylon bushing — brass tab

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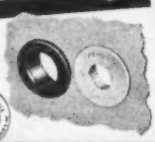

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PRODUCTS	CRCA BULLETIN #
Rotohmeters*: Minute, Ultra-Precision User Adjusted Resistors	R-65
Plug-Trims* Plug-in Resistors and Socket Blocks for Divider, Decade or Trimmer Assemblies	R-55
Instruments: .0002% Voltage Dividers .01% Wheatstone Bridges .01% Resistance Decades	R-50
Banana-Plugs Resistors*: Axial, Radial, & One Sided Types, Also Jacks	R-44
R-Stacks*: Multi-Tap, Fixed and Adjustable Resistors and Dividers	R-40
Series "200's": Standard design Lug and Wire Lead Resistors	R-28

*Patents Applied For

For abbreviated performance data see specs below or EEM, 1960 edition, page 1263.

GENERAL RESISTOR SPECIFICATIONS

Type:	Wire-wound, also carbon and metal film.
Range:	.01 ohms thru 20 Megohms
Absolute accuracy:	1% thru .005% (at 25°C)
Relative accuracy:	thru .001%
Long term stability:	thru .001%
Temp. coefficient:	thru 2 ppm/°C.
Power dissipation:	thru 3 watts at 125° V.
MIL. Specs:	MIL-R-93A and MIL-R-9444 (applicable sections)
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tronics laboratory at the Eclipse-Pioneer Division of Bendix.

General Kinetics Names Chief Engineer

JOHN K. O'CONNOR has been appointed chief engineer of General Kinetics Inc., Arlington, Va. He has been with the company since 1957 serving as staff mechanical engineer and project engineer on a variety of products including the development of ultrasonic film and tape cleaners and magnetic tape testers.

Amphenol-Borg Appoints Alessio

SERGIO A. ALESSIO has been appointed senior staff engineer, staff research and engineering, Amphenol-Borg Electronics Corp., Broadview, Ill.

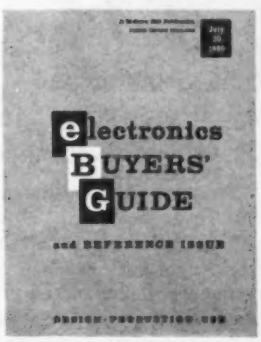
For the past four years, he has been associated with Bell and Gossett Dualex Division and Panellit, Inc., where he had major responsibility for design and development of digital data processing systems and components.

Electrada Selects Executive V-P

HENRY C. JONES has been named executive vice-president and director

Did You Know That Your 1960 electronics *BUYERS' GUIDE Includes . . .*

Missiles in Production	p. R5
List of Military Procurement Locations and Personnel	p. R7
Characteristics of Plastics	p. R34
Characteristics of Laminates	p. R36
Wire, Tape and Foam Specifications	p. R38
Symbols Dictionary	p. R42
List of Industry Organizations, Services and Standards	p. R47
Military Standards	p. R50
Military Nomenclature	p. R53



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of operations of The Electrada Corp, Beverly Hills, Calif. He joined Electrada in July, after 18 years in executive positions at Convair.

In his new post, Jones will have overall responsibility for the operations of the parent corporation and its five subsidiaries and divisions.

Electrada is engaged in manufacturing and research programs in the fields of space age instrumentation, data processing, and data retrieval.

Semi-Elements Names Director of Research

MICHAEL HACSKAYLO, a solid state physicist, formerly with the National Aeronautics Space Agency, Cleveland, O., has been appointed director of research for Semi-Elements, Inc., Saxonburg, Pa.

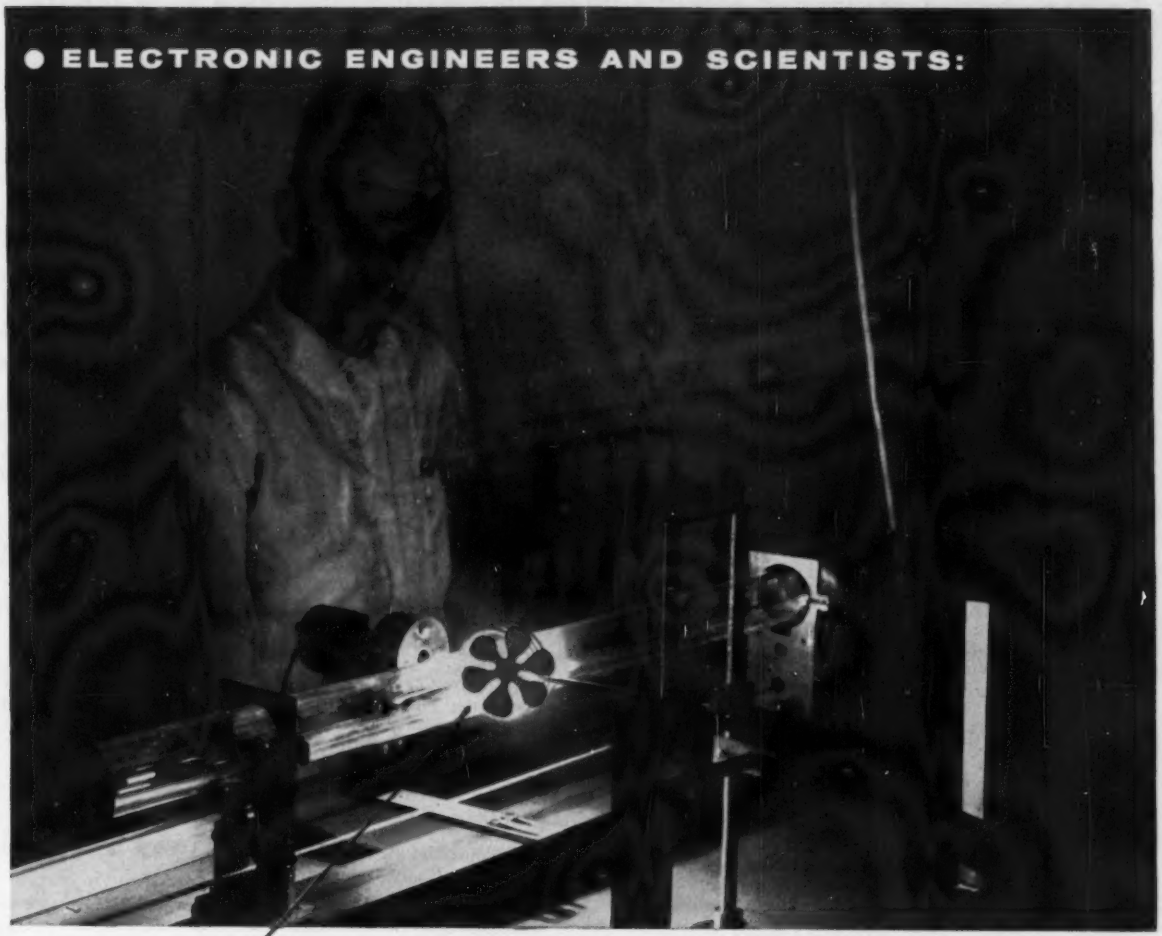
He will head a stepped up program being undertaken in new product development and will be responsible for basic research.

Computer Systems, Inc. Picks General Manager

W. A. OGLETREE has joined Computer Systems, Inc., Monmouth Junction, N. J., as general manager.

He was formerly with Burroughs Corp., where he served as manager of engineering for the military electronic computer division.

● ELECTRONIC ENGINEERS AND SCIENTISTS:



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- **SENSORS.** MS in Physics or Electrical Engineering with 12-15 years experience in Electronic Systems and Sub-Systems. Skilled in Radar, Infrared devices, Optics, Ultrasonic Techniques, Systems Integration, Countermeasures and Counter-countermeasures.

- **DATA PROCESSING.** BS in Physics/Electrical Engineering with 12-15 years experience in Electronic Sub-systems, Computer Theory and Practice, Background in Computer Logic, Computer Systems and Components, Cryogenics, Network Theory.

- **CONTROL SYSTEMS.** BS in Physics, Aerodynamics, or Math with 10-12 years experience in Aerodynamics, Applied Math. Skilled in Stability, Analysis, Mathematics (Laplace transforms), Servo-mechanism Theory, Computer Design.

- **GUIDANCE and CONTROL.** MS in Physics, Math or Aerodynamics with 12-15 years experience in Applied Math, Aerodynamics, Computer Techniques. Skilled in Stability Analysis, Servo-mechanics, Electronic Navigation, Systems Analysis, Computer Systems.

- **COMMUNICATIONS.** BS in Electrical Engineering or Physics, with 10-12 years experience in Electrical Engineering for Communications, Telephone-Telegraph Theory, Radio Transmitters and Receivers, Radio Propagation, Countermeasures and Counter-countermeasures, Security Coding.

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This fast-expanding and autonomous department has the following key openings:

- **ENERGY CONVERSION ENGINEERS** for static inverters, converters and frequency changers for military, space and commercial applications. Minimum 4 years experience with design-development background in aircraft and industrial power supplies and generating systems.

  Be familiar with as many of the following as possible: switching characteristics of transistors, silicon controller rectifiers and four layer diodes, transformers, interstage and power—filters, signal level and power—voltage regulators—polyphase circuits—heat transfer—packaging—power generating system specifications.

- **DIGITAL COMPUTER SYSTEMS ENGINEERS.** Electronics, Math or Physics degree and at least five years experience in design, development and analysis of digital circuits or computers. Be familiar with computer organization, logical design, statistical theory of information and/or communication, pulsed data systems and switching circuits. Knowledge of magnetic core or solid state devices desirable.

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- **RESEARCH ENGINEER,** Physics or Electronics with at least 5 years R&D experience in mechanization processes involving manufacture of electronic tubes or semi-conductor or nuclear products. Desire individual with diverse background, particularly heavy in high vacuum technology to conduct studies involving automated processes in electron beam machine technology.

- **DEVELOPMENT TEST ENGINEER,** Electronics for development work on electrical components of electron beam equipment. Should have thorough knowledge of 1 or more: 1. high voltage supplies; 2. electromagnetics; 3. electronic circuits; 4. electron beam formation and control; 5. data programming techniques.

- **TEST ENGINEERS** . . . electronic, electrical and mechanical.

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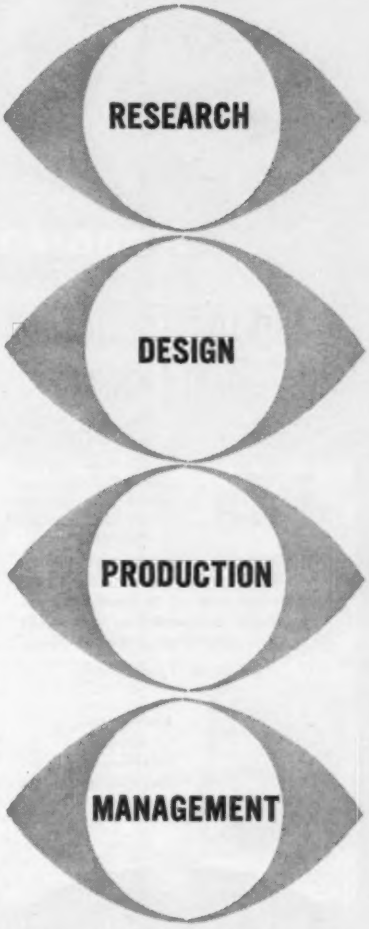

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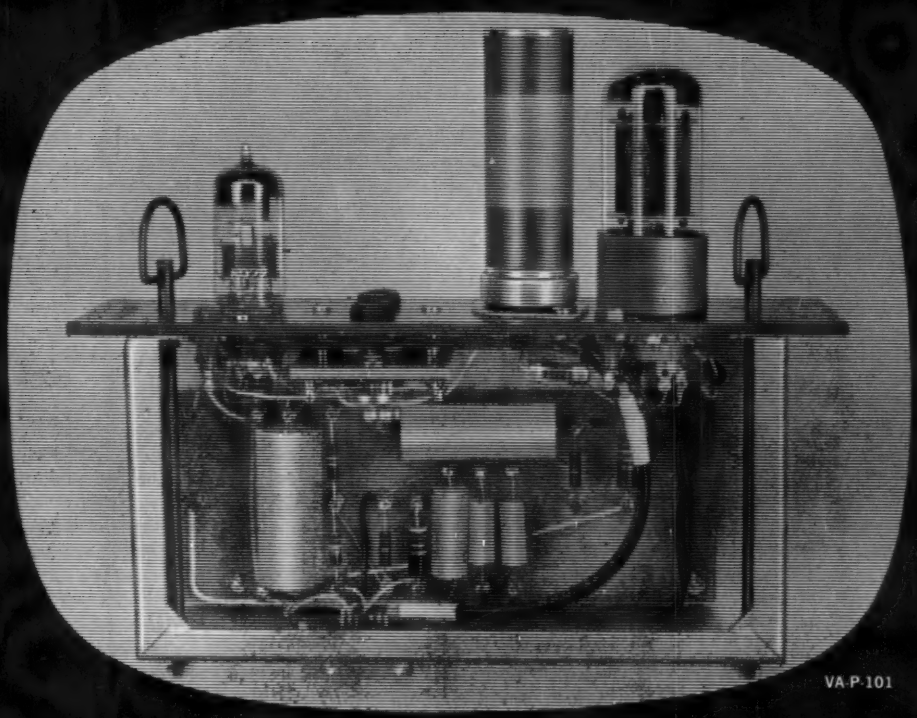

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VA-P-103	1 in/1 out Video Dist. Amp.	+3db	0.7 Volt	1	Flat ±2% to at least 8.0mc	0.7% max	0.35° max	60 ma
VA-P-201-0	1 in/3 out Video Dist. Amp.	Unity	1 Volt	3	Flat ±2% to at least 8.0mc	0.7% max	0.35° max	125 ma
VA-P-201-3	1 in/3 out Video Dist. Amp.	+3db	0.7 Volt	3	Flat ±2% to at least 8.0mc	0.7% max	0.35° max	125 ma
VA-P-201-6	1 in/3 out Video Dist. Amp.	+6db	0.5 Volt	3	Flat ±2% to at least 8.0mc	0.7% max	0.35° max	125 ma
VA-P-202	Sync Adder for VA-P-201 Amps.	—	4 Volts	1 to 3	—	—	—	30 ma
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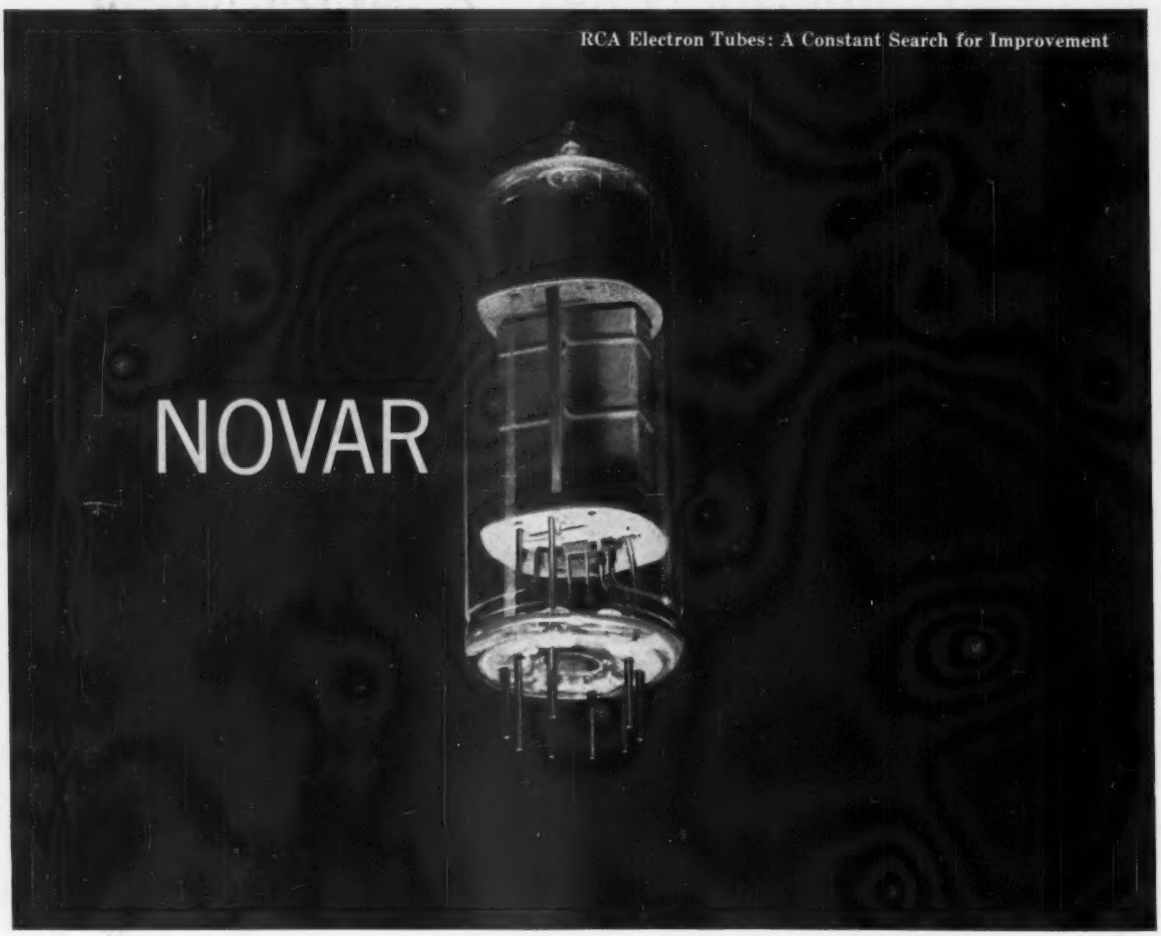

A STATEMENT TO THE INDUSTRY

In recent months, several leading tube manufacturers have issued statements and product notices regarding new large receiving-type tubes having an all-glass base instead of the conventional plastic base.

With great pride, RCA announces its new line of NOVAR receiving tubes. These types, which are now being sampled developmentally to the industry, reflect the careful effort made by our engineers to design a product that has low initial cost and low replacement cost; top quality; and simplicity of installation and conversion.

The new NOVAR tube has a 9-pin base with a pin-circle diameter of .687" and a pin length of .350". Most important, the inner leads used in NOVAR tubes have a diameter of 30 mils. Thus, the NOVAR tube types have a strong cage support and feature high heat-dissipation capability. Relatively cooler operation can therefore be expected from NOVAR types with consequent improvements in tube reliability and life.

Of equal importance is the wide distance between pins in the NOVAR tubes: .212". As a result the new RCA types can withstand high voltage gradients between pins. In other tubes using relatively close spacings, voltage breakdown between pins will occur at much lower values when all pins are used. It is evident, therefore, that certain families of tubes would be very difficult to design using a base with close pin spacings.

There is another factor. NOVAR tubes offer outstanding versatility. There is no function presently served by "octal" tubes that cannot be duplicated by the new RCA NOVAR line. In addition, these tubes will be priced lower than their present "octal" counterparts.

RCA believes that the introduction of NOVAR tubes represents a logical and realistic approach to the design of large glass-based receiving tubes. During 1961, as the new tubes are installed in a variety of home entertainment equipment, we are sure that our approach will be commended: that the development of the NOVAR line will have outstanding significance in the manufacture of finer, more reliable electronics components.

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